Frank Moore

A NEW SYSTEM
OF
SCIENTIFIC PROCEDURE

BY
G. SPILLER

AUTHOR OF "THE MIND OF MAN", ETC.

LONDON
WATTS & CO.
17 JOHNSON'S COURT, FLEET STREET, E.C.

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A NEW SYSTEM
OF
SCIENTIFIC PROCEDURE

BEING

AN ATTEMPT TO ASCERTAIN, DEVELOP, AND
SYSTEMATISE THE GENERAL METHODS
EMPLOYED IN MODERN ENQUIRIES
AT THEIR BEST

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1921

"Mais comment apprendre à bien conduire ses sens?
En faisant ce que nous avons fait lorsque nous les avons
bien conduits."

Condillac.

"Neither the naked hand nor the understanding left to
itself can effect much. It is by instruments and helps
that the work is done, which are as much wanted for
the understanding as for the hand."

Bacon.

"Ich sag' es dir: Ein Kerl, der spekuliert,
Ist wie ein Tier auf dürrer Heide,
Von einem bösen Geist im Kreis herumgeführt,
Und rings umher liegt schöne grüne Weide."

Goethe.

"La science s'avance parce qu'elle n'est sûre de rien."

Duclaux.

"Natural philosophy is essentially united in all its
departments, through all of which one spirit reigns and
one method of inquiry applies."

Sir John Herschel.

"The logic of Science is the universal Logic, applicable
to all inquiries in which man can engage."

J. S. Mill.

DEDICATED
TO
THE IMPERISHABLE MEMORY
OF
FRANCIS BACON
THE FOUNDER OF SCIENTIFIC METHODOLOGY

1607185

PREFACE.

The present treatise may be regarded as an attempt at a modern re-statement of Bacon's position in his *Novum Organum*, and this principally because the author follows the great Elizabethan in his suspicion of all precipitate theorising and in his conviction that the human mind may be made incalculably more effective for the discovery of truth than it has hitherto been. Like Bacon, he deems it eccentric to expect of men a high degree of methodological competency, so long as there exists no science of correct thinking grounded on a circumspect and exhaustive analysis of the process of thought at its best. Until such a science is established, the author opines, the progress of the sciences generally, especially those relating to the individual and to society, will be both snail-like and ant-like.

This demand for a *science* of correct thinking—not hasty or laborious speculations on the subject—is so eminently rational that it is difficult to imagine how any soberly reflecting person can forbear echoing it, whilst in respect of the obstacles which might be encountered in such a truly formidable enterprise, there should be agreement that these obstacles must be, manifestly, objectively discovered, not hypothetically created.

The author faintly hopes that, as a result of over a quarter of a century of indefatigable attention to the methodological problem, he has substantially advanced by this contribution the state of the science to which all the other sciences turn for light, as the planets do to the sun. On the principles he has adopted, there should be at last a possibility of changing the whirling chaos in the psychological, moral, economic, and kindred sciences into a steady and relatively swift forward movement—to the intense relief and immense benefit of the entire human race. Moreover, whatever the problem or issue that might arise, fair assistance towards its examination and resolution will be probably found in this work by those who have assimilated its proposals.

These pages have a predominantly practical object—to aid the inquirer in any investigation, extensive or restricted, which

he may desire to undertake. On this account the problems of the nature of reality, of knowledge, and of the categories of thought, have been left severely alone, and even the question of whether science presents us with a vision of eternal truth or offers only convenient conceptual models of a precarious kind has been brushed aside. Such a course does not involve a contemptuous dismissal of ancient and modern controversies on a variety of philosophical topics, or even a doubt as to their penetrating significance, but rather a desire to avoid all needless complications and to fix the attention on the practical aspect of the methodological problem. In fact, the composing of these controversies can evidently not be hoped for anterior to the establishment of an effective methodology. Accordingly, *the centre of gravity of this treatise must be sought in Book II*, where a series of working Conclusions have been formulated, and only secondarily in Book I, the primary intention of which is to clear the way for a due appreciation of the Book it precedes.

In conclusion, the author desires cordially to thank those who at diverse times read through the work in typescript and assisted him by valuable suggestions, most especially Prof. Patrick Geddes, Prof. J. H. Muirhead, and Dr. Cecil Desch.

The work has been completed abroad under considerable difficulties, entailing certain unavoidable shortcomings in regard to bibliography, indexes, and verification of sources. My warmest thanks are due to the staff of the printing office, more especially to its manager, my friend J. Šafránek, who practically saw the work through the press, reducing the author's co-operation to a negligible minimum.

Geneva, 1921.

G. SPILLER.

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PRELIMINARY CONSIDERATIONS.

I.—FUNDAMENTAL ASSUMPTION OF THIS TREATISE.

§ 1. A System of Scientific Procedure? Whewell¹ held that an art of discovery is impossible, and, as if by contrast, Macaulay² argued that all men instinctively practised this art. Other thinkers have assured us that by familiarising ourselves with any one science, our entire mode of thought becomes of necessity scientific; and still others that each science is unique, and that consequently there cannot be a single methodology embracing the whole field of knowledge. Finally, there are few who do not shake their heads at the suggestion of framing rules for the right conduct of the understanding.

Lest the reader, impregnated with views such as those just alluded to, lay this treatise aside without reading it, or peruse it convinced that its underlying conception is vitiated by a gross fallacy, it will be well to outline in this and the following paragraphs the fundamental assumption pervading the whole work. Whether we note the remarkably slow progress through æons upon æons in the development of implements, or the infinite efforts which have yielded modern science in all its incompleteness; whether we observe how microscopically small have been the individual contributions of the men and women of far renown, as we shall see, compared to the vast stock of human acquisitions existing in this age, or the sick man's pace in the evolution of political and economic institutions, we become equally confirmed in our belief that the individual is first and foremost a cultural being, vitally dependent on general human progress, and virtually a zero if thrown back on himself.

To cast this thought in the form of a tentative definition: Man alone is primarily a civilisable or culturable being, that is, Man alone possesses the power to absorb the substantial part of a highly developed civilisation, together with the ability of advancing this civilisation to an infinitesimal degree; or, stated more abstractly and broadly, the stock of humanity's

¹ See § 17.

² See § 57.

acquisitions, divided by the number of human beings who have lived, allowing for the actual physical and cultural conditions, approximately yields the single individual's intellectual, moral, and other capacities for invention and discovery. From this definition, if substantially correct, it follows that the unaided individual, reared in a cultureless environment, looms indifferently above his cousins, the apes. Fairly and squarely facing the facts of general historical development from the most primitive times to our day—the gigantic evolution of intercommunication through language and transport, of buildings and furniture, of implements and industrial processes, of domesticated animals and cultivated plants, of discovered energies and raw materials, of trade and tribal intercourse to internationalism, of dress and education, of play and pastimes and the inner life and its expression, of nutrition and care of health, of morals and religion, of science and art, of the family and other non-civic groupings, of civic groupings, government, and law—small doubt should remain in regard to the general soundness of the above position.¹ (For some details, see Conclusion 13.)

We may consider here with advantage the signification of three connected expressions.

Culture is a term which is frequently, but unwarrantably, confused with intellectual culture. Those who do so should remember that it is common to speak of physical culture; that there are organisations in many countries calling themselves societies for ethical culture;² and that the phrase artistic or æsthetic culture is not unknown. Culture, then, simply implies cultivation, whether it be that of the soil, of the intelligence, of moral and æsthetic sentiments, or of practical ability, on the basis of the inventions and discoveries made by the human race. Culture, in other words, is a comprehensive term to be employed in contradistinction to native power or spontaneity. He who is truly cultured, is highly cultivated in respect of every important part of his nature.

Secondly. It is often asserted that culture is a social product. The term social provides, however, no insight into the fact that virtually the whole of humanity, from earliest times to to-day, is collectively responsible for the contemporary store of general culture. Alternative terms, such as inter-individual, inter-social, super-social, are alike unsatisfactory because of their indefiniteness. A new term is therefore required. In our generation we have heard much of Pan-Germans, Pan-Slavs, Pan-Islamists, terms expressive of a universal category. Profiting by the current use of *pan* as an adjective and adverb, we may speak of culture as *pan-human*. The

¹ A signal example of collective advance is furnished by the fact that the Royal Society, the Accademia del Cimento of Florence, the Académie Royale at Paris, and the Berlin Academy were founded within a few years of each other, plainly indicating a trend of the times rather than the embodiment of novel ideas occurring to exceptionally gifted individuals.

² Mill (*System of Logic*, bk. 6, ch. 10, § 2) speaks of "intellectual und moral culture".

term employed in this form would render it at once plain that our culture is, for all intents, the cumulative product of the efforts of all mankind past and present, and no doubt enthusiasts will be found who will go further and speak of a pan-humanist movement and of themselves as pan-humanists.

Lastly. For the reasons stated in the immediately preceding paragraph, the term sociology appears to be misleading. It is generally taken to mean that human beings live in groups; but since many animal species live also in groups, the term does not hint at any distinctively human characteristic. What is more, since man depends primarily on culture and culture is a pan-human product, he is not a social, but a pan-species being—a being whose mode of life is intimately related to, although not identical with, that of his kind as a whole. Consequently, the term sociology expresses a fact which holds of many animal species, but not of man. We need, therefore, a term which shall have reference to man's essential dependence on culture, and which shall, if possible, embody the conception that culture is primarily a cumulative species-product. We might accordingly speak of *specio-psychics*, to indicate that culture is the product of the spiritual endeavours of the whole of humanity. Understanding, then, Specio-Psychics to be the equivalent of "science of pan-species culture", we may regard it as concerned with one of the leading aspects of nature, and constituting with Physics (the science of the inanimate) and Biology (the science of the animate) the three most distinctive departments of existence, to be ultimately subsumed under Cosmology (the science of the whole).

Strictly interpreting our definition, there is practically nothing which we can profitably leave to the individual as such. A tendency towards co-operation extending to all ages and all lands is, accordingly, the very life-breath of human society, and so far as this factor is absent there is minimal advance, stagnation, or retrogression, disguised maybe by ignorance, prejudice, and the weaving of mazes of error. However, since truth is so difficult of attainment, aimless co-operation argues profuse waste of energy, and co-operation should therefore be informed by science which should consequently penetrate every nook and cranny of human life. Even our views on health and on happiness, the moral and the matrimonial relations, the nurture and the education of the young, the methods of workmanship and trading, our social affairs and politics, our arts and our relations to near neighbours and distant peoples as well as to domestic and wild animals, our thought and our inner life—all should be clarified and guided by considerations drawn from a highly developed methodology, if they are not to remain in perpetuity emblematical of confusion and of twilight.

We ought hence to assume that the scientific mode of thinking is a slowly developing product of pan-human civilisation, and that with the passing of the ages, and as the result of mountains of experience, man gradually discovers how to

employ his understanding most effectively.¹ It appears, therefore, right and proper to reject the narrowly individualistic conception of human nature and human reason, which traces the origin of leading methodological concepts to the superior minds of a few distinguished thinkers, and to posit the liberating and the perfecting of the human intelligence through pan-humanly developed methods of thought. Our great men, we shall see, are first and foremost historic milestones; they conveniently, ably, and enthusiastically summarise for us the larger and more definite results of an epoch in a specific direction.

II.—THE UNITY OF NATURE AND OF LIFE.

§ 2. The nineteenth century established in the minds of men the concept of *the uniformity of nature*. No longer, therefore, can it be asserted, without calling forth emphatic and almost universal protest, that objects alter their nature indifferently, or that there are countless occult forces whose activities make reliance on experiment fatally precarious.² Men affirm now boldly, and in the very act of affirming they lay the foundations of science, that given a certain cause a certain effect will invariably follow under certain defined natural conditions.

It will be the privilege of the twentieth century to lodge in the human mind the notion of *the unity of nature*. The concept is yet far from having been generally assimilated. There are not a few men who consider that action at a distance should be assumed as a simple fact, and that it savours of metaphysics to seek for the proto-element or stuff out of which the chemical elements have possibly been formed. Others not only doubt whether we shall ever know intimately the stellar regions or the world of atoms, but they discern a break between non-

¹ See § 73 for a historical analysis.

² "Pendant des siècles, les hommes ont cru que même les minéraux n'étaient pas régis par des lois définies, mais pouvaient prendre toutes les formes et toutes les propriétés possibles pourvu qu'une volonté suffisamment puissante s'y appliquât. On croyait que certaines formules ou certains gestes avaient la vertu de transformer un corps brut en un être vivant, un homme en un animal ou une plante, et inversement." (E. Durkheim, in *De la méthode dans les sciences*, 1910, p. 308.)

"In the 17th century Alexander Ross, commenting on Sir Thomas Browne's doubt as to whether mice may be bred by putrefaction, flays his antagonist in the following words: 'So may we doubt whether in cheese and timber worms are generated, or if beetles and wasps in cow-dung, or if butterflies, locusts, shell-fish, snails, eels, and such like, be procreated of putrefied matter, which is to receive the form of that creature to which it is by formative power disposed. To question this is to question reason, sense, and experience. If he doubts this, let him go to Egypt, and there he will find the

living and living substance, between animals and man, and most especially between mind and matter. And widely prevalent is the view which insists upon the ultimate mystery and inexplicability of the Universe.

Such a *non possumus* attitude acts as a relentless brake on the man of science, since at every stride forward which he desires to make there are voices warning him that it would be presumptuous to strive to pierce to the depths or to attempt to connect what is separated by an impassable gulf. Theoretically such an attitude may not only appear plausible, but seems even to reflect the cautious scientific thinker in opposition to the reckless amateur; yet, once such a principle is granted, the scope of science might be caused to shrink to a mathematical point. Fortunately, men of science have possessed a splendid and sturdy faith which has been amply justified by results, and consequently the hypercautious counsellors and critics are doomed to be disappointed.¹

fields swarming with the mice begot of the mud of Nylus, to the great calamity of the inhabitants.'” (W. A. Locy, *Biology and its Makers*, 1908, p. 278.)

Shakespeare's lines on the bee reflect the fanciful science of his day:

“*Cant.* True: therefore doth heaven divide
The state of man in divers functions,
Setting endeavour in continual motion;
To which is fixèd, as an aim or butt,
Obedience: for so work the honey-bees;
Creatures that by a rule in nature teach
The act of order to a peopled kingdom.
They have a king, and officers of sorts:
Where some, like magistrates, correct at home,
Others, like merchants, venture trade abroad;
Others, like soldiers, armèd in their stings,
Make boot upon the summer's velvet buds;
Which pillage they with merry march bring home
To the tent-royal of their emperor:
Who, busied in his majesty, surveys
The singing masons building roofs of gold;
The civil citizens kneading up the honey;
The poor mechanic porters crowding in
Their heavy burdens at his narrow gate;
The sad-eyed justice, with his surly hum,
Deliv'ring o'er to executors pale
The lazy yawning drone.”

(*King Henry V.*, Act 1, Scene 2.)

See also *Studies in the History and Method of Science*, ed. by Charles Singer, 1917; and L. Thorndike, *Natural Science in the Middle Ages*, 1915.

¹ “The character of the true philosopher is to hope all things not impossible, and to believe all things not unreasonable. He who has seen obscurities which appeared impenetrable in physical and mathematical

One scientific division after another has been swept away by the torrential stream of time. The theory of gravitation furnished the first signal indication of the unity obtaining in nature, and in recent days astro-physics and astro-chemistry have further confirmed this. The doctrine of the conservation of matter has been succeeded by the doctrine of the conservation of energy. As a result of a series of discoveries ranging over a century, we have recognised the feasibility of linking up most of the main forces in nature—heat, light, electricity, magnetism, and, possibly, chemical affinity. Thus, again, it has been shown that by lowering sufficiently its temperature, every gas can be ultimately reduced to a liquid and probably to a solid, and that, therefore, we have grounds for believing that the three states of matter—gaseous, liquid, and solid—are due to definite calorific differences. Once more, the boasted barriers between the elements are gradually being removed. If carbon can exist in four different states; if oxygen can possess an allotropic form; if the arrangement of the elements in order of their atomic weights evidences such striking relations between them that the discovery of new elements having certain properties can be predicted; and if elements are actually produced by the transmutation of other elements, it almost betokens intellectual obstinacy to doubt that the day is approaching when the simple chemical substances known to us will be proved to be compounds of one element or compound—perhaps of hydrogen, perhaps of some lighter element yet unknown, who can tell? Nor need we fear that the present-day telescope and microscope have the last word to say in the exploration of the far-off spaces and the more intimate structures of bodies.

In biology the advance has not been less real, for the evolution of plant and animal life is now acknowledged universally, and it is even exceptional to-day for any scholar to suggest that man has not developed from a lower form. The old notion of a vital chemistry has lost most of its scientific supporters, and the struggle rages at the moment only round the mode of the genesis of life itself. Who can doubt where the victory will lie, if history and cumulative evidence are trustworthy guides? The compartment theory unfortunately still holds the

science suddenly dispelled, and the most barren and unpromising fields of enquiry converted, as if by inspiration, into rich and inexhaustible springs of knowledge and power on a simple change of our point of view, or by merely bringing to bear on them some principle which it never occurred before to try, will surely be the very last to acquiesce in any dispiriting prospects of either the present or future destinies of mankind." (Sir John Herschel, *Discourse on the Study of Natural Philosophy*, 1830, [5].)

field in psychology. Signs are, however, not wanting that feeling, intellect, and volition will at no very distant date be demonstrated to be complexes rather than primordial facts; that all the sensations will be proved to be resolvable into the same fundamental fact as the just-mentioned triad; and that psychology will be regarded as the science which treats of the neural or mental processes employed in the endeavour to satisfy the needs which arise out of the various connected systems of the organism and out of the relations of that organism to its environment. Similarly, the pan-human origin of culture involves that the polygenetic theory of human purposes and actions is ill-founded, whilst the rise of the "scientific management"-movement suggests that theoretical and practical activities will be eventually governed by a single and undivided scientific methodology. Furthermore, Mach and others, the present author included, have proposed reasons for surmising that the idea of a rigid division between matter and mind may be traceable to inadequate analysis, and that the two are perhaps one, not as the materialist, idealist, or pantheist, suspects, but in the sense that the alleged separateness, duality, or difference is non-existent.

Sufficient has been advanced to suggest that the conception of the unity of nature is no longer a gratuitous assumption destitute of probability and proof, even though we are still groping for an explanation of gravitation and its complement cohesion, and even though we cannot yet indulge in dogmatic utterances of any kind.

The bearing of the doctrine of the unity of nature on the methodology of science is manifest, for just as there was practically no scope for a methodology when the uniformity of nature was denied, so, in the absence of the doctrine of the unity of nature, the methodologist is bound hand and foot. Once, however, there is limitless freedom for the man of science, the methodologist can ceaselessly reiterate his cardinal postulate, *i.e.*, the advisability and necessity of advancing in the boldest manner possible wherever a legitimate opportunity presents itself. The objective foundations, then, of the methodology of science are laid in the comprehensive twin doctrine of the uniformity and unity of nature.

Now just as the uniformity of nature involves uniformity in every department of existence without exception, so the unity of nature carries with it the unity of all departments whatsoever. In other words, the unity of nature implies the unity of outward nature as well as of life. This leads us far beyond

the confines of science as delimited by the founders of the Royal Society. In those far-off days science signified natural philosophy, and natural philosophy was content to explore the realm of what we designate to-day as physics, including her handmaiden, mathematics. Since that period the double term natural philosophy has been transformed into the single term science, and the connotation of the latter term has been restlessly expanded. One physical science after another was added to the few which first existed, while slowly, very slowly, the biological sciences vindicated their right to be classed methodologically with the physical sciences.

The royal domain of systematised knowledge hence assumed vaster proportions. The wheel of progress did not, however, come to a standstill when this stage had been reached. One by one the cultural or specio-psychical sciences proved at least their theoretical right to enter the charmed circle of the established sciences. Economists led the way; psychologists and sociologists followed; and, in time, not one department of cultural knowledge remained which could be justifiably regarded as falling outside the coveted pale.

Even so, however, the domain of science had to be further extended. From the very dawn of systematising, the line between pure and applied science had proved elusive, and accordingly it was only to be anticipated that the expansion of science should tend to the development of a series of more or less avowed applied sciences. Indeed, one distinguished man of science after another became responsible for important scientific applications to departments of practice requiring the same methods of enquiry as the so-called pure sciences. The introduction of gas light, and afterwards of electric lighting, heating, and motor power, was an instance in point, and so were the inventions and discoveries due to the need for communal sanitation and for the prevention of infectious diseases, and previous to that the application of astronomical truths and of the compass to navigation, whilst the universal employment of machinery and scientific instruments furnished the case *par excellence*. The desire for economy in industries, and also for the utilisation of waste products and the improvement of agriculture, similarly issued in applied scientific activity of prime value. Naturally, once science was found to be lucrative in the economic world, it was more and more wooed. Manufacturing companies employed scientific staffs for the specific purpose of deriving the fullest benefits from science applied to their sphere of activity; natural substances—such as diamonds,

rubies, indigo, and rubber—were artificially produced; and universities and technical schools, observing this, began to pay increased, often excessive, attention to applied science and to scientific preparation in every practical department. Moreover, psychological tests of generic or specific efficiency were eagerly, perhaps hastily, utilised by industrial and commercial enterprises. Thus action and reaction between theoretical science, education, and applied science continued until, as at the present day, the three are closely welded together into an integral totality. If, perchance, on the one hand, much remains still to be done to apply science in the economic world, yet, on the other hand, there exists here and there a deplorable tendency to neglect in favour of this the no less fundamental, but more theoretical, aspects.

Manifestly, there could be no restriction of applied science to the economic life. Criminologists entered on extensive studies of the criminal, his environment, and the means of reforming or deterring him. Eugenists warmly interested themselves in the question of how to discourage the increase of the tainted, and encourage the augmentation of the healthy, "stocks" among men and, of course, among animals and plants. Educators busied themselves with child study and psychology in order to elevate the children in accordance with scientific methods. Politicians, with a taste for science, examined the psychology of the crowd or collective man. Hygienists sought to discover the best diet, physical exercise, and clothing, and generally the best methods of keeping the body supple and strong, and, as mental hygienists, the best means of preserving intellectual and moral sanity and virility. And, alas! mainly for aggressive purposes, the armaments of the nations have been, with the aid of science, prodigiously raised in destructive power. It is, therefore, only a question of time that the whole of practical existence—from the lowliest material needs to our loftiest aspirations—will be moulded and illuminated by scientific insight. We should, in fact, not forget that the uses, application, production, quality, value, desire, liking, love, enjoyment, and preference of phenomena—the utilisation of things—are but certain aspects of the one Existence. (See the Table of Primary Categories in Conclusion 3.)

Again. A great science has been evolving during the last quarter of a century whose object it is to replace the tentative rule-of-thumb methods obtaining in industry and commerce by rigidly scientific ones. No longer are haphazard traditions and shortsighted common sense to govern the modes of production

and distribution. Every type of process is to be exhaustively studied in order that it might be reconstructed on scientific principles, ensuring ideal economy in movements, speed, effort, thought, and the like, and products of the highest quality. (See Conclusion 10.) So thorough is this new movement that it is likely not only to revolutionise industry and commerce, but science itself, by standardising universal modes of procedure of a startlingly exacting character.

Lastly. The major and minor arts, whose mission it is to irradiate beauty and joy in the highest as in the humblest spheres, must become part of the infinite empire of the one all-enveloping and all-connecting science, with its single and all-sufficient scientific method.

Accordingly, the unity of nature must be acknowledged to embrace inanimate and animate existence, including human life in its various aspects; and a scientific methodology—*itself one and indivisible* (Conclusion 2)—has therefore no boundaries of any kind. The only reservation to be made is that it will be some time yet before the later and latest sciences will be fully worthy of being classed among the “established” sciences. Rome was not built in a day!¹

Nor should we omit to notice the unity of the historic process. Contrary to first impressions, we shall find, on closer examination, that the expansion of the province of science is also a natural one, the relative maturity of a lower or less complicated branch of learning creating the possibility of the formation of a slightly higher and more complicated branch of learning. The fierce struggles for recognition by individual disciplines should be therefore regarded as virtual epiphenomena, as being due primarily to the difficulty of settling the justice of claims, no doubt aggravated by neither party adequately appreciating the objective nature of the problem before them.

¹ The attempt has been made to distinguish between science as that which teaches us to know and art as that which teaches us to do. Medicine is thus considered as an art in contradistinction to physiology which is described as a science. Yet to understand the normal and abnormal workings of the organism, and how to prevent and destroy physiological disequilibrium, assuredly involves identical methodological processes. The scientific physician may, indeed, manifest a purely theoretical interest in his labours; but even if his interest should be practical, this would merely argue a special direction of scientific activity. The distinction, then, between a science and an art is, at least for the present and the future, methodologically a dubious one, and refers to motive and object rather than to mode of procedure. Science might be defined as primarily exact and systematised knowledge as such, and true art as primarily exact and systematised knowledge restricted to practical and idealistic ends.

The applicability of scientific procedure to life and mind has, however, been called in question. M. Henri Bergson, in his *L'Évolution créatrice*, reasons that science is powerless to investigate super-physical processes. His argument is based on the contention that the object of the intellect is to promote action, and that this action concerns itself with inanimate matter. Hence, M. Bergson concludes, the triumphs of science in physics, and its dismal failure in biology and sociology. In criticism of this attitude the following doubts may be advanced. If the object of the intellect were to promote action, action in animals is in great measure, perhaps mainly, concerned with themselves and with fellow animals; and, moreover, if science has thus far accomplished much in physics and little in biology, this is only to be anticipated considering the primitive simplicity of the subject-matter in the first, and the staggering complexity of the subject matter in the second, department of knowledge. The alternative, to have recourse to intuition—a very nebulous term—in reaching the verities of life, is unsatisfactory, in view of the fact that “intuition” has been so employed for ages, with fatuously trivial and contradictory results. The unclouded intellect appears to us to have proved itself equal to the study of any known subject, however complicated; only that we cannot hope to grasp the complex as rapidly as the simple, nor to solve the most abstruse problems without the aid of an advanced methodology. As an illustration of the complexity of biological facts, consider the following case:

“Take, for example, those small capsules which are found in the kidneys at the very summit, so to speak, of the problem of renal secretion. These small bodies each occupy a space of less than two-thousandths of a cubic millimetre. Within their interior they contain different kinds of blood-vessels that represent the structures of greatest mechanical interest when dealing with the circulatory system, omitting, of course, the heart. This almost complete sample of the circulatory mechanism, itself formed of a congeries of parts and unitary mechanisms, is enclosed by two or three thousand cells of specific glandular function. Every one of these cells again is a complex of mechanisms about which we cannot rightly think until we reduce our conceptions to the level of molecular dimensions. Enclosed, then, in this minute space, within a mass that weighs two thousandths of a milligramme, lie quite a series of the problems in which physiology is interested.” (Opening Address by Prof. J. S. Macdonald, President of the Physiology Section of the British Association, 1911.)

It is for this reason that, for instance, protein compounds are exceedingly difficult to isolate and study, first, because of their close resemblance to one another; secondly, because of their complexity—*e.g.*, the approximate formula for hæmoglobin is $C_{158}H_{123}N_{195}O_{218}FeS_3$; and thirdly, because they

can only be built up by a series of complex transformations. Even the specialisation common in science will be progressively superseded, as more and more general facts of a scientific order accumulate.

Men of science need not therefore be intimidated by the suggestion that nature possesses no unity, or that the world of life and mind can only be effectively explored by the intuitionist.¹

III.—THE METHODOLOGIST'S PROCEDURE.

§ 3. A modern methodology of science should be the outcome of an analysis of modern scientific procedure at its best; and yet such an analysis is well-nigh impossible, since what is offered to us in publications are final results which veil, rather than disclose, the concrete movements of the mind. As the analyst of Darwin's method states: "The scientist, after establishing a conclusion to his own satisfaction, is not concerned with telling other people how he reached it, but with convincing them of its truth." (Frank Cramer, *The Method of Darwin*, 1896, p. 22.) For this reason it might appear necessary that the methodologist should be an adept in most sciences; but here, again, the task imposed is more than human. The author has, therefore, chosen a third road which Condillac already clearly perceived when he wrote: "Mais comment apprendre à conduire ses sens? En faisant ce que nous avons fait lorsque nous les avons bien conduits." That is, we circumspectly observe ourselves whilst we are occupied in thinking, take diligently note of the ratiocinative successes we score, warily apply as universally as possible to subsequent thought what we have learnt, and by dint of persistent examination and experiment we discover and realise, to express it theoretically, the most effective methods of thinking.

Yet, at the threshold, an initial obstacle has to be surmounted, for every-day thought is far from interesting, arduous, or coherent. On this account the present author spent several years in preparing a text-book of psychology based on original research,² and engaged on other large and definite tasks, in order to find opportunities for examining his mind when

¹ "The biologist deals with a vast number of properties of objects, and his inductions will not be completed, I fear, for ages to come; but when they are, his science will be as deductive and as exact as the mathematics themselves." (T. H. Huxley, *Twelve Lectures and Essays*, "The Educational Value of the Natural History Sciences", ed. 1915, p. 14.)

² *The Mind of Man*, pp. 568, London, 1902.

systematically and strenuously at work, and so as to apply and test the results of his studies.

Self-examination and self-training are, however, not likely to be sufficiently far-reaching, because it is very probable that, after every allowance has been made, peculiar grooves of thought and blank ignorance have to be taken into account. Accordingly, self-examination was supplemented by a study of the great methodologists, by wading through libraries of books on science, by perusing many of the works and the biographies of the foremost thinkers of the race, by interviews, by visits to laboratories, and, not least, by submitting successive drafts of the typescript to competent scholars. In this way, it is hoped, the personal equation was substantially rectified, and thus a fair understanding reached of general scientific procedure.

When it is considered what diverse methods have been applied through the ages in seeking to comprehend the world, and also that modern psychologists are agreed that the process of intellection presents no mystery, it will be conceded that there is nothing monstrous or fantastic in the endeavour to ascertain how man thinks at his best, and how to compress this mode of thought into definite and utilisable statements.

IV.—THE METHODOLOGIST AS SCIENTIFIC DISCOVERER.

§ 4. Readers might be inclined to test the proposed methodology by what its propagator has achieved thereby. They might contend that if a scientific methodology is to help men to assured and rapid advance in science, the methodologist, inasmuch as he has found the pearl of great price, should substantiate this by his discoveries. Accordingly, the readers of this treatise may be tempted to search in its pages for a long chain of novel and epochal scientific truths.

The temptation to argue in this manner may appear warrantable at first sight; but further consideration will, we hope to show, evince its unreasonableness. The duty of the elaborator of a scientific methodology is, plainly, to evolve a methodology, not to exploit it. From the very commencement of his attempt to its consummation, he is ever groping his way, and slowly, very slowly, assisting to create a relative cosmos where previously a relative chaos prevailed. Even if he could devote a whole life-time to his enterprise, and was peculiarly fitted for it, he would still require all the hours at his disposal to prevent his methodology from being more imperfect than necessary. He would be, therefore, obliged to publish his work long be-

fore he had truly completed it, and consequently he would lack the time to apply his conclusions systematically in several directions.

Moreover, this Methodology does not profess to furnish a method whereby large numbers of important truths can be arrived at by one individual; it rather suggests that the establishment of comprehensive generalisations and deductions is the task of ages and the effect of systematic co-operation. Its aim is as much to warn against individual over-confidence as to point to correct methods. Its keynote being the unity of knowledge and the necessity of being satisfied with incomplete conclusions for prolonged periods, no one should expect to discover in these pages an imperial mint for the wholesale production of scientific truths.

Finally, theory and practice, analysis and synthesis, are not identical. A good dramatic critic need not necessarily be a good dramatist, nor does it follow as a matter of course that a methodologist should be skilful in the application of scientific methods. Indeed, the very absence of adroitness and the very hesitancy in decision, not improbably provide the occasions which reveal the manifold methodological factors involved in scientific activity.

The object of the methodologist is to supply the most finished instrument of investigation he is capable of devising; but the extensive employment of this instrument he must leave to others who have not had the disadvantage of consecrating a long life to its laborious construction and even more laborious multiple revision. If, therefore, in the succeeding pages, most of the profound observations are not original, and most of the original observations are not profound, it is hoped that the reader will regard this as inevitable, as in the nature of things, and not as reflecting unfavourably on the endeavour to place before the world a comparatively ambitious work on methodology.¹

¹ See, however, the author's *The Mind of Man* and his *The Distinctive Nature of Man* (shortly to be published), for an attempted application of the methodological viewpoint urged in these pages.

BOOK I.
THEORY.

PART I. THE PROBLEM.

SECTION I.—ABSOLUTISM AND RELATIVISM IN METHODOLOGY.

§ 5. The unity of the world of fact does not strike the ordinary observer, because for his purposes a world divided and subdivided into many independent parts and compartments is a more profitable conception. Slight variations, border instances, minute, remote, and invisible objects, as well as slow transformations, escape him. Such being the case, it was natural that the pioneer logicians of the West should have unsuspectingly assumed that the ordinary spectator's point of view is the correct one, and that they should have consequently taken for granted the existence of the world of common sense, that is, of a world composed of isolated objects and isolated classes of objects with features too plain to be overlooked. This mode of apprehending facts supplied a rigid criterion for the processes of reasoning, and hence followed the absolutist character of the older logic. A trait of this kind, since it appeared to ensure certainty, was, reasonably enough, cherished beyond anything else in the armoury of logic.

Francis Bacon, although he ardently expressed his belief in "progressive stages of certainty", only fitfully applied this pregnant conception of his. The notion of the correlation and unity of the natural forces and of phenomena generally, or of the ultimate relations and reducibility of the elements, did not suggest itself to him. It is true that he boldly sought for the "simple natures" of things,¹ and that nothing less than the discovery of these would satisfy him; but it was *simple natures*—heaviness, malleability, fixity, fluidity, colour, etc., which he was bent on discovering, not *simple nature*, nor did he apparently suspect that the molecular world was the world of master facts, and that this world could only be approached with the greatest difficulty, if at all. For this reason he, like Aristotle, believed in the molar and compartment theory of the world and of the mind, and to this is partly attributable his exaggerated opinion as to what a perfected scientific method might

¹ Francis Bacon frequently employs the term Form, and he offers as equivalents of this term nature, law, simple nature, specific difference, true definition, etc. By Form he almost certainly means what in modern terminology is called Natural Law. (*Novum Organum*, bk. 2, 3.)

accomplish if applied by even one adept. Had he divined the interdependent unity of nature, as the latest science is increasingly forcing it on our attention, he would have certainly admitted that the most admirable of methods should allow for progressive stages of certainty as regards conclusions, and for an organic and historic development of the structure of knowledge from the simple to the complex. He would have therefore emphatically repudiated the idea of remaining reconciled for a time to probable or incomplete results—*e.g.*, to X-rays, cathode-rays, and Lenard-rays,¹ whose precise nature is as yet a mystery, or to accessory food factors such as fat-soluble *A*, water-soluble *B*, and the anti-scorbutic factor, where the functions are only partially known and the chemical nature not at all.

It was this same laudable craving for certainty which obscured for Descartes the practical value of the inductive method, and which prevailed on him to exert his genius to the fullest measure in order to elaborate a system of knowledge which should remorselessly exclude all uncertainty. On this account, he made in his *Regulae* a highly ingenious attempt—by accentuating intuitional truth, and coupling this with a stern deductive procedure where every movement is rigorously checked—to comprehend the Universe without an appeal to general experience. Descartes was even jealous of the reasoning process, and hence he proposed to fuse, through repeated attempts, the links of a reasoning process, till it became one and intuitional in character.² From the point of view of the end aimed at, Descartes' attitude was irreproachable; only he was unfortunately mistaken in his assumption that either the reasoning process or the external world was composed of discrete elements void of intricate and subtle interrelations. He rightly distrusted reliance on the senses because of the evident heterogeneity of what is presented to observation; but he failed to appreciate that words, being but symbols, are even more elusive than facts, and that the most trifling slip in a complicated train of reasoning may throw us altogether off the track, whilst no amount of foresight can prevent such slips from occurring where facts are not appealed to unceasingly.³

¹ The X-rays are now practically identified with the gamma-rays of the radio-active substances, and much is known concerning them, and the cathode-rays are now said to consist of streams of negatively charged particles or electrons.

² On the above, see the *Regulae*; also Boyce Gibson on these in *Mind*.

³ Leibniz drew up rules referring to probable knowledge. His second rule in his *L'art de bien raisonner* reads: "When it does not seem possible to attain to certainty, one must content oneself with probability." (Couturat, *La logique de Leibnitz*.) The following formal rules of his specially refer to this type of knowledge: "(1) Distinguish degrees of probability. (2) A conclusion is never more probable than the principle from which it is deduced. (3) When a conclusion is deduced from several principles which are only probable, the conclusion is less probable than any of those principles." (*Ibid.*, p. 180.)

John Stuart Mill, though an empiricist in philosophy, was nevertheless, like his distinguished predecessors, an absolutist in logic. He set little store by approximate generalisations, and looked on them as definite though incomplete; his identification of inductive with causal investigations was apparently due to his desire of disposing of something once for all; his canons demanded proofs as unerring as those of the syllogism; and his repeated use of letters of the alphabet to symbolise the various unknown factors in a problem, illustrated how oversimple was his conception of the Universe. The methodological guidance he proposes is consequently only applicable in the main to the concluding stages of an enquiry when bewilderment has ceased and the principal facts are established and classified.

Sheer indefinable probability, a groping one's way in the dark, a chaos growing gradually less confused, a thinker feebly illuminating a humble corner here and there or slightly intensifying the light; in other words, the plastic form of the actual process of concrete enquiry had not impressed itself upon the older logicians. They were concerned with final products, not with complicated and elusive facts; nor did they treat of hypotheses, generalisations, and certainties of an unfolding and progressive character. Even where, as in Laplace's theory, probability was postulated, it was of a calculable character, and not of the undefined quality which almost invariably attaches to investigations as they develop under the hands of generations of men of science, as say in the progressive discovery of the nature of flame, in the slow determination of the principal causes of meteorological changes, in the gradual localisation of the sensory and motor areas in the brain, in the involved unravelling of the problem of heredity, or in the step-by-step ascertainment of the nature of a perfect diet. Likewise in our new century there are few savants who adequately recognise that the most learned treatise written on any subject to-day is bound to be comparatively crude because of its dependence on other treatises which are being or will be written, *e.g.*, a treatise on what education should be depends, among other developments, on a perfected science of hygiene, psychology, ethics, æsthetics, and technology, and on something like unexceptionable physical, economic, intellectual, political, and moral conditions in society as a whole. This interdependence is noticeable throughout the groups of sciences, beginning with the least dependent and terminating with the most dependent—elementary mathematics, mechanics, ethereology, chemistry, crystallography, biology, psychology, and the cultural or specio-psychical sciences,¹ there being "scarcely any natural phenomenon which can be fully and completely explained in all its

¹ For a classification of the sciences, see Conclusion 33.

circumstances, without a union of several perhaps of all, the sciences" (Sir John Herschel, *Discourse*, [183.]), a sentiment which the eminent physicist Lord Kelvin endorses by saying: "All the properties of matter are so closely connected that we can scarcely imagine one *thoroughly explained*, without our seeing its relation to all the others, without, in fact, having the explanation of all." (*The Constitution of Matter*, 1901, p. 240.) The common experience of one science dividing into a number of others is a further verification of the above contention: "By a law whose necessity is evident, each branch of the scientific system gradually separates from the trunk when it has developed far enough to admit of separate cultivation." (Auguste Comte, *The Fundamental Principles of the Positive Philosophy*, ed. 1905, p. 31.)

Some logicians have also thought that only instinct, sagacity, imagination, and other alleged unanalysable mental qualities can be advantageously utilised in the process of scientific enquiry. As opposed to this view, *i.e.*, that scientific ability is an indeterminate *X*, and science itself necessarily absolute, we shall endeavour to show in the sequel that an art of reasoning relating to greater or smaller probabilities of an imperfectly calculable character has developed through the ages, and may be abstracted from the present practice of men of science. Some writers on logic (Bosanquet, in his *Logic*, and Creighton, in his *Introductory Logic*) argue that the reasoning process presents a developing unity; and it is to be hoped that logicians generally will recognise that progressive stages of proof and of certainty deserve to be circumstantially treated in works on logic.

Psychologists have spoken of the psychologist's fallacy. One might with equal justice speak of the logician's fallacy. The final product of a process of reasoning stated in formal terms has been mistaken for the expression of the concrete process itself, and reasoning in formal terms and modes has been assumed as the only mode of reasoning. Logic is, however, a progressive science, as we shall see. (Section VI.) In proportion as convention favours the utilisation or the neglect of hypotheses, so men accustom themselves to the one or the other; as generalising is or is not encouraged, or as abstract or concrete, dignified or petty interests prevail, so men adjust their thoughts in conformity with the social trend; and when reliance on books or on imaginative treatment rules, when it is the fashion to think with or without aids, formally or informally, the scientific mass mind faithfully reflects each of these trends. This being the case, it may be conjectured, with some degree of certainty, that the average individual of the somewhat distant future—as the eventual result of the discovery and the assimilation by the masses of mankind of the modes of thought which time has ripened, and which the modern scientist at his best applies when engaged in expert investi-

gations—will possess a general power of analysis and synthesis, a general capacity of bringing to light what is concealed and correctly extracting the variety of implications of a fact or a statement, which has heretofore only existed among distinguished men of science when they dealt with particular problems familiar to them. Unfortunately, the subject of the education of man is too gigantic to be approached within the narrow limits of this treatise, and we have therefore largely restricted ourselves to an analysis of the mental process employed in scientific discovery.

We may, however, add that the primitive chaotic conception of the world, as pictured by the fetichist and afterwards by the polytheist, and even by a Lucretius, is being more and more reduced to order by science—as witness the gravitational and astronomical conception of the Universe; the geological, meteorological, geographical, cartographical, racial, and political conception of the earth; our knowledge of the atmosphere, its constituents, and its movements; the general facts of inorganic and organic chemistry; the theories of the evolution of worlds and of living forms; the insight gained into the static and dynamic nature of the cell; the ascertained anatomy and physiology of the members of the vegetable and animal kingdoms; the knowledge of man's story and nature gained through archeology and scientific history; the tolerable comprehension of the furniture of man's mind and the stages of his life; the wonderful instruments which are at the disposal of captains of industry and men of science; the enlightenment traceable to the aid rendered by mathematics and geometry and the systematisation of sense knowledge; the internationalisation of ethical, political, economic, and scientific methods; the development of universal rules of conduct; and the spread of taste and of refinement—and that, with the ages, it will become increasingly easy to grasp and comprehend the world of facts. Thus in time the main forces and uniformities in nature will be discovered and systematised, and man's outer and inner life more or less completely understood and ordered. Hence absolutist doctrines and deductive methods of a severely mathematical character will, in the course of time, become more and more applicable, until, on the advent of the mythic stage, when the world formula has been evolved and the ultra-microscopic and ultra-telescopic facts of nature have been revealed in their pristine simplicity and hammered together into a series of facts or into one fact by inter-planetary co-operation, Descartes' fascinating dream of intuitively apprehending the Universe will be actualised. On the present age rests the humbler and more prosaic task of promoting a general comprehension of the mental processes involved in the best contemporary scientific practice, and of urging the reasoned application of the fruits of such an endeavour to all spheres of possible investigation and activity. An abso-

lutist methodology will therefore become practicable only in the remote future, when the present state of knowledge will have been almost infinitely transcended, that is, when most of the leading facts of physics, biology, and specio-physics, will have been ascertained and correlated into a closely-knit science of the cosmos or cosmology.

In the succeeding four Sections we shall discuss the scientific acumen to be anticipated from individuals who are not deliberately trained in accordance with methodological canons faithfully abstracted from modern scientific procedure at its best.

SECTION II.—THE INFANT AND CHILD MIND.¹

§ 6. Men often smile at the extravagant conclusions reached by children (as when a child who has heard that a driver, arriving from a certain village, is called Leonard, inquires whether all drivers hailing from that locality bear this name); yet a circumspect study of infant life throws some light on the problems of methodology.

We need not touch here on inherited aptitudes, or on the learning, without imitation, of certain movements (such as carrying the fingers to the mouth), nor the interesting stages when by degrees concerted action ensues between pairs of eyes and limbs, or collaboration develops between the several senses. To enter into these genetic problems would lead us too far afield.

The first concept of interest to us which the child acquires is that of "things". The eyes supply the infant with its information about the world beyond the finger tips, but this only when objects move, omitting here strong light and glaring colours which fascinate rather than teach anything. Hence when the child watches a curtain moved by the wind, an animated face, a figure passing by, the waving branches of trees, the inrushing tide, it gradually singles out the moving object from the motionless surroundings. Only motion, on our part, or on the part of a portion of our environment, appears to yield the individuality and separateness which adults associate with things.

At first, objects which pass out of sight or out of the grasp have passed out of existence for the child; but diverse experiences teach him that out of sight is only out of mind. The first truths learnt, then, by the infant are that objects exist and persist; and, in an unreasoned way, no doubt, he becomes convinced that all things exist and persist for ever in the precise form in which he has sensed them.

The next stage is an equally important one. Motion has unlocked the secret of things, and now stationary objects, first

¹ See under Child in the Index of the author's *The Mind of Man*.

small ones and then large ones, are, to begin with, recognised and then freely distinguished. A pencil, a glove, a hat, a chair, a table; a little later a door, a wardrobe; and later still, a house, a street, are separated with astonishing ease by the eye.¹ Yet the word table, for instance, is not interpreted by the child to mean: "This something, seen at this moment from this angle." Rather will the child identify as a table any table at any time, or even anything resembling a table. Thus sandals, slippers, shoes, and boots are shoes; all round objects are balls; every glass vessel is a glass. Given one object seen and named, the child readily regards it as representing a class. The reason for this tendency to generalise is probably as follows. The child's glance is only arrested by the leading features of the object, and he observes it therefore most incompletely. Hence size, colour, variations in shape, position, and the like, are very imperfectly apprehended, and the general and particular are thus readily confounded. When, therefore, an object appears a second time, or a similar object presents itself, vague memory followed on loose observation will identify what is more or less heterogeneous. Secondly, even so far as differences are appreciated, they are nevertheless neglected because not deemed of importance, or, to express this more objectively, because only the known and that which interests fall within the focus. For the child Generalisation signifies psychologically that a certain object—or what is for him the same, a certain class of objects—having been once singled out will, because of the neural mechanism or the laws of association, be automatically isolated when it reappears.

The infant is practically incapable of associating one object of one class with another of a different class. His griefs and his joys are unaffected by any recollections or reflections, since these are lacking, and reasoning, which implies cross-classification of memories or associated recollection, is therefore absent. A time, however, arrives when—after the invaluable repetitive stage of earlier childhood has passed where every action tends to be repeated a number of times—the association of memories and ideas becomes possible, especially with the aid of language. When this happens, random, though not frequent, generalisations as to relations and classes of facts follow in the wake of the similarly random, but frequent, generalisations as to separate facts. Until much later, when his store of knowledge has assumed considerable proportions, the child's interest is predominantly concerned with facts rather than with classes of these.

¹ The sense of touch, as a channel of external information, apparently develops relatively late in the infant life of the individual. Besides, this sense supplies only an infinitesimal portion of our knowledge of the Universe, and its high philosophical status is not easily vindicated before the bar of fact.

If the child's method of attacking problems developed from within, his world of ideas might automatically grow to be organised and compact on approaching adulthood. As a matter of fact, however, the modes of mental reaction beyond the early animal stage are furnished by the cultural environment, and hence, after the Rubicon of infancy is passed, his discriminations and classifications reflect in a rudimentary form this environment which, as we shall see in the next Section, has hitherto normally occupied a low scientific plane. That is to say, since the cultural environment varies indefinitely in space and time, and since methodical thinking is as yet socially unorganised, we may expect children to develop a perplexing number of markedly ineffective ways of approaching the everyday problems of life. This we actually observe to be the case. According to the opportunities afforded, and the conditions of the social environment, we note in the young the profoundest cultural divergences—some are grossly ignorant, others are excellently informed; some are stupid, others are brilliant; some are credulous to a degree, others judiciously discriminate. Especially if our survey be historical and geographical, do we discern prodigious and capricious deviations in intellection, moral insight, taste, and practical ability, manifestly determined by cultural and not by hereditary factors. We are therefore prepared to find that since the great majority of children receive but a poor educational equipment, and live under anything but ideal cultural conditions, they should exhibit as a class a very modest methodological status. Following the child from infancy to adolescence, we are thus struck with his essential dependence culturally on human advance as a whole, on the constitution of his social environment, and on the nature of his personal circumstances.

We note, therefore, in the child two characteristics: (*a*) the development of the chief elements in the growth of thought—the impulse to know, apprehension of objects, observation, generalisation, imagination, reasoning, judgment, and, above all, profiting by the inventions and discoveries of others, and (*b*) the absence of anything resembling the circumspection, comprehensiveness, and systematic procedure of scientific method, except in so far as highly efficient methodological teaching and training are provided.

We will enquire now to what extent, intellectually, the ordinary scientifically untrained adult differs from the child whose offspring he is.

SECTION III.—THE SCIENTIFICALLY UNTRAINED ADULT.

§ 7. Prior to the formation of mental associations connected with events in his life, the child does not deliberate. In the course of growing older, however, he gains an enormous stock

of memories, and the possible number of associations becomes therefore limitless. Consequently, especially with the priceless aid of language, the process of deliberating, of reflecting, of reasoning, steadily develops with experience and with guidance, and in this particular respect there is, accordingly, a notable distinction between the younger child and the average adult. Still, the deviation, if we omit the earliest stages, is much less clear between adult and child so far as the processes of intelligence are concerned, for, although the half-trained adult will neither mistake the almonds on a cake for pebbles nor assert that the chair is naughty, his cogitations only very remotely suggest modern scientific procedure at its best.

The average man to-day labours under peculiar disadvantages from which the man of science is exempt. The latter does not grudge the expenditure of the time and energy requisite for solving a problem, and, what is more, if no tangible solution is forthcoming, as in Faraday's attempt to detect a relation between gravity and other natural forces, he merely postpones or abandons the search for an explanation. The average man, on the contrary, is compelled to settle every day numerous problems, and he is, therefore, little perturbed when any of his ordinary solutions prove partially or wholly erroneous.

To generalise is a matter of mental economy both in practical life and in science, and in practical life economy is of such moment that probability quickly reached is more prized than certainty attained as the reward of protracted labours. The average adult, no doubt, generalises excessively; but, on the other hand, mere cautiousness is of doubtful positive value. In certain strata of society "I think", "It appears to me", "I don't know", are expressions in constant use. Precipitate generalising is avoided here; but mechanical caution neither dispels error nor extends the horizon of knowledge. In the keen struggle for existence much must be staked, and indecision will not feed, clothe, house, or enlighten mankind.

Consider an instance of every-day problems. The train by which a person travels to town has been occasionally late. That person, if he desired to be precise in recording the fact, would need to state the number of times the train has or has not been late; the dates, the hours of the day, and any special circumstances which might account for the tardy arrival of the trains. Rather than conduct such an elaborate investigation, he would prefer to proffer no statement at all, and yet a purely negative attitude on all dubious points would tend towards a mental standstill. Aware of these obstacles, we are satisfied in daily life with probabilities, and we seldom strive to attain to even approximate certainty. What, then, is the current measure of the degree of probability? The question is embarrassing. Not a few individuals universalise in an extravagant manner. If, for instance, a train chances to be late,

the remark is made that all trains on the line in question are late in arriving, or, more forcibly, that there is always something amiss with trains. A single act stamps a man as good or bad, and an isolated transaction determines whether a tradesman is a desirable person to have dealings with or not. Similarly, manners, political parties, and religions—other than our own—are freely condemned on the basis of one or a few instances, whereas one or a few picked illustrations are presumed to demonstrate the superiority of our manners, political party, and religion. Likewise there is no argument so shallow or unsubstantial which is not often regarded by numbers of men as conclusive when it is, say, a matter of defending class interests or inventing an excuse for declaring war.¹

In the absence of a discriminating public standard of probability it is hazardous to pass judgment on the average man for indulging in precipitate statements. After all, the Universe is not a multiverse. To-day closely resembles yesterday, and to-morrow will not differ much from to-day. The general facts of nature do not sensibly vary during brief periods; towns, parks, streets, houses, remain virtually the same from week to week; the number and the appearance of the folk we encounter in our district from day to day remain approximately alike; and our acquaintances apparently possess a permanent character. Moreover, largely because we are trained to ignore everything which is not palpable, obvious, or usable, the marvellous development of plants and animals from shapeless and diminutive zygotes into astonishingly varied forms; the links which closely connect the most diverse living types; the world of causes which is almost invariably the region of the microscopic and ultra-microscopic; and objects relatively distant in space and time, fall outside the focus of common apprehension and interest. Nor does fortuitous experience teach a man much, for an undisciplined and confused memory, multitudinous prejudices, and rambling cogitations re-reduce the complex to the simple, and mask the deeper truths. The method of thought whereby he ordinarily proceeds, the average man opines, is applicable everywhere. Besides, because of the intricacy of most problems, it is difficult to prove to him that he is mistaken, and even if he be convicted of a defect in his reasoning, he will readily discover specious explanations to reassure himself. Thus, if a man of ill repute happens to be drowned when swimming at the seaside, it is regarded by many as a divine punishment; if a man of good repute is drowned under analogous circumstances, the deity is said to have need of him. If unemployment increases in the country,

¹ The World War, happily ended with the defeat of the principal aggressor, painfully illustrates the last point. Austria's pretext for attacking Serbia, Germany's for declaring war on Belgium, Russia, and France, and Bulgaria's excuse for breaking with its neighbour, Serbia, are apt examples.

the Opposition attributes it to the incompetence of the Government, whilst Ministers of State ascribe it to the disturbing effect on the market of the unwarrantable and partisan criticisms of the Opposition.

However, prejudice is immensely heightened by a mental process the presence of which is habitually unsuspected, namely, the psychological fact, to be discussed in Conclusion 7, that only that which appeals to us tends to be recalled. For this reason, the Musulman, the Jew, and the Christian; the Conservative, the Liberal, and the Socialist; the aristocrat, the bourgeois, and the operative; the artist, the captain of industry, and the man of the world, are each very often supremely confident in their views. The opponent's contention, because of the working of the psychic mechanism, has no justification for them, and hence they feel immovably certain that their case is strong, and that of their antagonist weak. In one limited sphere alone the average man reasons scientifically, or nearly so, namely in his avocation, where a knowledge of many of the relevant facts and traditional methods resulting from dearly-bought experience, frequently prevent slipshod observation, reasoning, and generalisation. Since, however, he is not conscious¹ of the peculiarity of the method which he applies in his avocation, this method is of no assistance to him in any other department of life, especially because occasions vary and divergent situations require relatively divergent treatment. Nevertheless, even here, as the efficiency movement is daily demonstrating, a multitude of blighting prejudices seriously debases the value of his thought.

The average individual of to-day is not only hampered by ignorance, bias, and narrow sympathies; he generally lacks the determinate and desirable qualities which efficient training provides. When confronted with a perplexing problem, he just stares at it, loses heart, or seeks to overcome it by attempts ascribable to the most fugitive suggestions; when he discovers two or three trivial points, he deems that he has discovered everything relevant; when an unfamiliar theory is propounded, he thinks of some more or less plausible objection, and decides at once that this disposes of the theory; every novel suggestion relating to practice he stigmatises as unpractical or as contrary to human nature; when a solution does not quickly present itself, he conjectures that no solution is possible; he confounds mere plausibility with sheer truth; each ephemeral symptom he regards as an independent and fundamental fact, overlooking thus what is really of moment and far-reaching; he believes that if he only waits, the truth will automatically sail into view; he despairs of there being any truth at all in the matter;

¹ An analysis of the nature of habit will be found in the author's *The Mind of Man*, Ch. 3.

he is not concerned about finding the truth; he hesitates and vacillates; he is unmethodical; he occupies his time in brooding and speculating, in grumbling or fumbling; he does not attack the problem with sufficient energy; he has not learnt to construct or to follow a lengthy train of reasoning; he jumps to conclusions; he is without resource; he is not sufficiently cautious; memory plays him false, and he forgets much; he takes no accurate notes, nor does he make sure of his facts; and so on, and so on.¹

Every competent observer will corroborate the statement that average persons exhibit some or many of the defects above mentioned, defects which bring into relief the need of a methodology. It is evident, then, that thinking in conformity with scientific standards is most rare among the scientifically untrained, and it is at least a problem worth examining whether proper methodological training, which is now curiously conspicuous by its absence, would not mend matters materially, if not radically. It is difficult to see why defects such as those enumerated in the preceding paragraph could not be eradicated, and the corresponding desirable qualities firmly implanted. Indeed, it is as unreasonable to anticipate that the *untrained* thinker will be equal to the task of thinking effectively as that he will not become expert in this direction when adequately trained. The very growth to an illimitable extent of scientific methods affords further presumptive evidence in favour of the assumption that methodological thinking is a socio-historic and pan-human product.

Let us now study the man who is “scientifically” trained, in order to enable us to determine what distinguishes him from the scientifically untrained adult.

SECTION IV.—THE SCIENTIFICALLY TRAINED INDIVIDUAL.

§ 8. The theory and the practice of the sciences are commonly assimilated by the student in the course of practical scientific work and reading. He surmises that his teachers proceed in certain ways, and imperceptibly he glides into those ways himself. Hence, since the material of the sciences differs notably in respect of composition and complexity, and since the stages in their development also diverge widely, it is not to be expected that the traditionally determined pursuit of some particular science will unlock the secret of the general scientific method. In some sciences, as in physiology, the facts are relatively complicated, whilst in others, as in molar mechanics, they are comparatively simple, and likewise the advanced stage

¹ Corresponding defects, equally due to absence of right habits, account for imperfect morals. The individual is as dependent here on inventions and discoveries as in engineering or chemistry.

of a science, owing to the presence of sifted facts and explanations, may allow of ready and speedy generalisation and deduction, whereas at the birth of a science the initial ignorance may compel exhaustive enquiries and tediously slow advance. Compare in this respect medieval alchemy with twentieth century chemistry. So, too, the application of experiment, of deduction, of mathematical formulæ, of comparative or genetic methods, depends on the subject matter and on the stage of development of any science. As a consequence, when the botanist, for example, turns to politics or to religion, one generally observes that there is no noteworthy distinction between the precariousness of his judgments and those of the typical politician or theologian.¹ Indeed, in his crude attempt to apply in a generalised form the methods he employs in his highly specialised science, he is not seldom grievously in error. Some of the scientific light sheds no doubt a weak, phosphorescent illumination over nearly his whole intellectual being; but this is of trifling account. The theory of teaching men to be scientific in their general thought by bringing them into contact with some particular science is, therefore, plausible, but nothing more.

The fallacy just referred to is interestingly illustrated by the fortunes of psychology. In its earliest phases, and among the ancients generally, it was allied to *metaphysics*. At a certain point, as with Wolff and Kant, it became *rational*. When scientific enquiries began to grow common, men thought, as in England from the time of Hobbes to James Mill, that the method of developing a science of the mind was to eschew transcendental considerations and cultivate speculative introspection—to which movement was due the *associationist* school. Herbart, who was much impressed with the grandeur of the science of physics and the value of mathematics, looked, in imitation of the physicists, upon ideas as isolated mind atoms governed by a law of levity, and endeavoured to explain the nature of the human mind by valuating these ideas and their relations *mathematically*. Fechner, following Weber, devoted himself to experiment, and constructed the science of *psycho-physics*. With Wundt psychology became predominantly *physiological*; and to-day the tendency is to place the emphasis on the *instincts* and on the *emotional and volitional life* generally, whilst new schools are emerging stressing the *psychology of the unconscious*, the aspect of *behaviour*, and the *native psychic powers* alleged to be revealed by psychological tests. Nor can we do more than allude to the efforts to comprehend the mind through the study of *abnormal states*, through the growth of mind in the *individual*, in *races*, and in *animal life*, or through all these combined. Whether a haven of rest has been reached by psy-

¹ The absence of a general methodology explains how men of scientific distinction are frequently found to be outrageously unscientific when passing judgment on problems outside their domain.

chologists, is more than questionable. Here we need only note the almost insuperable obstacles, due to subject-matter and stage of development which have to be encountered in transferring the traditional method of one science to another passing through a different phase. Ordinarily this is facilitated through one science imperceptibly developing out of a closely related one; but where there is a comparatively abrupt commencement, there, as in psychology and in the cultural sciences generally, owing to the lack of a scientific method of a general character, no manifest point of departure presents itself, and hence centuries may be lost in groping for the method proper to the new enquiry.

The same difficulty, having its origin in identical causes, is encountered in every attempt to skip several historic stages, and it is for this reason that the development of science has been so schematic—from the simple to the complex—and that “the history of science presents us with no example of an individual mind throwing itself far in advance of its contemporaries”.¹ (Brewster, *Life of Newton*, 1875, p. 112.) Mathematics, dealing at first with concrete and then with idealised data, came first. Then followed Astronomy (where only the most general facts were and are taken into consideration), Molar Mechanics² (which is almost wholly a question of judiciously defining the motions of visible masses of matter in space and time), Ethereology (concerned often with imperceptible, but yet relatively isolated, facts, such as gravity, heat, light, electricity, magnetism, rays), Chemistry (where the combination of elements introduces a new factor, complicated however by the existence of inert elements refusing to combine), Biology (which not only treats of highly complex chemical compounds, but also of the presence of intricate organic structures in the higher genera), Psychology (which depends on introspection, on a high and impartial standard of observation, and on a knowledge of the organism's, the individual's, and the community's development and needs), and the cultural sciences or specio-psychics (which re-

¹ Note that it is Newton's distinguished biographer who is responsible for this statement.

² “By far the most general phenomenon with which we are acquainted, and that which occurs most constantly, in every enquiry into which we enter, is motion, and its communication. Dynamics, then, or the science of force and motion, is thus placed at the head of all the sciences; and, happily for human knowledge, it is one in which the highest certainty is obtainable, a certainty no way inferior to mathematical demonstration. As its axioms are few, simple, and in the highest degree distinct and definite, so they have at the same time an immediate relation to geometrical quantity, space, time, and direction, and thus accommodate themselves with remarkable facility to geometrical reasoning. Accordingly, their consequences may be pursued, by arguments purely mathematical, to any extent, inasmuch that the limit of our knowledge of dynamics is determined only by that of pure mathematics, which is the case in no other branch of physical science.” (Sir John Herschel, *Discourse*, [87].)

quire extensive physical, biological, and psychological knowledge for their comprehension).¹ Evidently a general science of phenomena, or a philosophy, will remain an unrealisable hope until most of the sciences are firmly established, and have ascertained the majority of the most comprehensive truths in their respective spheres, together with most of the principal verities common to them.² At first sight our contention that scientific tradition begins in confusion as to subject-matter and method, seems belied by the clear line of advance from the simple sciences to the less simple ones which history chronicles. Further reflection, however, attests that man has always attempted to grapple with the subject-matter of most of the sciences, that is, that centuries of effort have been wasted in those cases, *e.g.*, in the biological sciences, where the subject-matter investigated is of a labyrinthine order, and presupposes the existence of certain as yet undeveloped sciences, *e.g.*, chemistry. It is, therefore, an irresistible conclusion that *scientific advance is only possible from the simple to the complex*, that the complex will be erroneously interpreted so long as the less complex has not been reduced to comparative simplicity, and that scientific advance must remain tiresomely slow until general scientific methods have been discovered and are generally accepted, freeing the individual from the trammels of empirical and misleading traditions and practices.

A fruitful definition of science can only be attempted when we restrict ourselves to asking What does science mean in *our* day? Broadly speaking, it signifies for us moderns the developing and connecting of certain departments of knowledge, such as theoretical and applied physics, biology, specio-psychics, and cosmology, and this by traditional methods far more circumspect than the ones commonly employed in practical life to-day. In its higher reaches it means further, as a rule, the endeavour to obtain a simple, unified, and incontrovertible view of nature and of life, through guarded and exhaustive observation, through subsequent bold and graded generalisation, and through verified deduction of the same type.³ When, therefore, we wax enthu-

¹ For a history of the classification of the sciences, see R. Flint, *Philosophy as Scientia Scientiarum*, and for a comprehensive scheme of classification, Conclusion 33.

² *E.g.*, note the complete dependence on fact of the argument in Henri Bergson's *Données immédiates*. The neglect which overtakes philosophers generally is primarily due to their reliance on crude observation and unsifted surmises.

³ "Experience presents to us a chaos of innumerable events, together and in succession. In this chaos, science has first to ascertain the facts; then, to ascertain 'what follows what', *i.e.*, what facts are invariably connected together; and then, to account for those regular connections, to show how or why they are so connected." (S. H. Mellone, *An Introductory Text-Book of Logic*, 1905, p. 291.) "A science is, in all cases, a systematic body of knowledge relating to some particular subject-matter." (James Welton, *A Manual of Logic*, 1896, vol. 1, p. 10.)

siastic about science, we have in mind chiefly the large results achieved since the Renaissance by the class of men conventionally called men of science, and the ingenious methods employed by them in research—use of instruments, experiment, and mathematics. Perhaps in a thousand years' time men will understand by science something as far outstripping in serviceableness modern science as modern science outdistances the science of Aristotle's and Averroes' days in this matter. There is no occult quality inherent in the word science, for the laxest magic and the severest inductive procedure occupy one rising plane.¹ Speculative or objective method, deductive or inductive method, represent historic phases, all of which appear, and even are, right at certain periods. Belief in dogma or rejection of authority is also immaterial to the historical definition of science. *The one distinguishing feature of the method of science observable historically is the progressive approximation to more and more successful methods of systematically, definitely, and convincingly establishing comprehensive uniformities.*

For our own day we should draw a somewhat sharp distinction between the world of science and the world of common sense. This distinction is manifestly justified when we reflect that to-day science aims primarily at theory and common sense primarily at practice. Whereas, therefore, the scientist is absorbed in understanding a microscopic section of existence, the layman generally thinks of how to procure comforts and luxuries. For this reason the layman perceives as a rule only the gross, coarse-grained facts, and is frequently interested in these alone, whilst his conclusions are crude ones, in harmony with his narrow experience and his homely wants. The scientist, on the other hand, esteems no effort too strenuous or too prolonged to achieve a slight advance in comprehending a small part of nature. Therefore, as the one invents machinery in order to augment wealth and render social life safe and tolerable and co-operates with his fellows to this end, so the other, joining with fellow-labourers, explores the rich mines of fact by means of special instruments and the most patient systematised thought. The one desires to possess the world; the other to comprehend it. In the present age, therefore, common knowledge and scientific knowledge, the world of practice and the world of theory, tend too frequently to lie far apart, with the significant exception of the applied sciences and arts, scientific management of industry and commerce,

¹ The following stages in the historical development of science may be roughly discriminated: unconsciousness of problems; magic; fetichism; polytheism and philosophy; Greek, Roman, and Eastern science; theism; Arab school; Aristotle revived; earlier and later renaissance; seventeenth and eighteenth century speculations, gropings, and advances; and the measurably superior speculations, gropings, and advances, of the nineteenth and twentieth centuries.

and hygiene, where both meet.¹ In the distant past this was not the case, because science, strictly speaking, was as yet scarcely developed; in the distant future this will be again different, for the scientific method will be, as we have already intimations to-day, a universal possession universally cherished and applied. Practice will then fraternise with theory, and theory be a close ally of practice. In essence, as we have seen, the world of experience is one and undivided, developing from wholly unsystematised and practical thought to wholly systematised and theoretico-practical cogitation.

More than two generations ago Comte proposed a solution of the problem of how far the man of science should subordinate his researches to the needs of practice. We present the solution in his own words, only premising that the needs of applied science, and those of industrial and commercial activities generally, increasingly demand the initiation of theoretical researches; that in not a few cases it has been found practicable to pass backwards and forwards from theoretical to applied sciences and arts; and that, indeed, with the gradual subjugation of many scientific and practical spheres, a compendious theoretico-practical treatment will be effected with facility, and therefore grow common. "Immense as are the services rendered to Industry by Science, and although according to the striking aphorism of Bacon—Knowledge is Power, we must never forget that the Sciences have a yet higher and more direct destination, that of satisfying the craving of our minds to know the laws of phenomena. . . . The general tendency of our time is, in this respect, defective and narrow. But, in the case of scientists, it is corrected, consciously or not, by the strong natural craving of which I have spoken. Otherwise the human intellect would be confined to researches of immediate practical utility, and, as Condorcet very justly remarked, would for that reason alone be completely arrested in its progress. This would be the case even as regards those practical applications to which we should have imprudently sacrificed the purely theoretical labours; for the most important practical applications are constantly derived from theories formed for purely scientific purposes, and which have often been cultivated during many centuries without producing any practical result. . . . It is, therefore, evident, that, after the *study* of nature has been conceived in a general way as serving for the rational basis of our *action* upon it, we must next proceed to theoretical researches, leaving wholly on one side every practical consideration. Our means for discovering truth are so feeble that if we do not concentrate them exclusively upon this object, and if we hamper our search for truth with the extraneous condition that it shall have some

¹ Theory owes already much to practice. "Pour préciser par quelques exemples les grands apports étrangers aux sciences naturelles qui les ont insensiblement créées ou périodiquement bouleversées, énumérons rapidement et pêle-mêle les sacrifices religieux de victimes animales et l'examen de leurs viscères, les voyages commerciaux des Egyptiens et des Phéniciens, les jeux du cirque dans la Rome impériale, la découverte de l'Amérique et les explorations ultérieures, la combinaison de lentilles qui fit le microscope, la pose des cables transatlantiques qui conduisit aux grands dragages abyssaux, les recherches de Pasteur que les besoins de la brasserie amenèrent par des études de chimie à transformer la biologie et la médecine." (Frédéric Houssay, *Nature et sciences naturelles*, about 1903, pp. 1-2.)

Thus chemistry had its origin in the desire for adornments, for fermented liquors, for dyes, and other useful articles, for medicines, and for transforming ordinary substances into gold. (See also Conclusion 32.)

immediate practical utility, it would be almost always impossible for us to succeed."¹ (*The Fundamental Principles of the Positive Philosophy*, ed. 1905, pp. 44-45.)

Under present circumstances the scientifically and unscientifically trained adult agree in being guided by tradition, only that in the former instance the method customarily employed is immensely superior. In the true sense, the scientifically trained adult will only come into being when a tried methodology introduces the student to the meaning and methods of science.

There is no valid reason why deliberate methodological training should be postponed to the distant future. Far easier than semi-conscious conjecturing and interpreting of supposed methods on the basis of a medley of half-sifted facts and fancies, would it be for students to be deliberately educated in conformity, say, with the thirty-six Conclusions contained in Book II of this volume. By a combined theoretical and practical study (see Conclusions 8 to 10) the learner would in this manner arrive at being tolerably proficient in reading the secrets of nature and of life. If we imagine every teacher fairly trained in this respect at his or her college, it is to be presumed that the general instruction, work, and life of the school (and, it is hoped, of the home) may become permeated with at least the elements of the scientific spirit, especially if we note that the world about the child offers boundless opportunities for purposeful, methodical, and exact observation, generalisation, and theoretical and practical deduction. What is true of the child is *a fortiori* truer still of the adolescent and of the young men and women of university age. It is most desirable therefore that the introduction of this more excellent way of acquiring scientific skill should not be indefinitely postponed. Men of science should be surely the last in the world to insist on continuing a tradition for no better reason than that it exists.

SECTION V.—THE MAN OF GENIUS, AND THOUGHT AS HABIT-CONTROLLED AND AS A PAN-HUMAN PRODUCT.

I.—THOUGHT AS HABIT-CONTROLLED.

§ 9. The super-chemistry of thought is more easily conceived in the abstract than concretely analysed. Stimulated by instincts and consequent desires, human thought enters the scene, and is primarily dependent for efficiency on a more or less complete and correlated memory. Yet, singularly enough, with all its perfection there is scarcely anything more imperfect than the human memory. First we note that our consciousness is almost like a sieve, for most of our sensations no sooner

¹ Comte's view was manifestly correct as far as the stage of scientific development of his day was concerned. To-day already his reasoning is only partially justified, and in the course of time it will become obsolete. On the subject generally consult Conclusion 2B.

present themselves than they bow themselves out of existence. What remains, after the sieving process, is the merest fraction of that which has been perceived, or what has passed through our mind. Add to this, a rapidly fading memory which progressively obliterates most recollections of a few years' standing, and plays such havoc with the residue that where there were images full of colour and definiteness, the barest elusive half-shadow survives, and our difficulties will be appreciated. Then there is the fact that memories become frequently confused, misleading, transmuted, and that they more often than not refuse to appear when they are summoned. The Dreyfus trial in France, a generation ago, afforded a striking object lesson in regard to the short and erratic career of memories.

However, it is not only that the memory is inherently an imperfect instrument, but the teleological or economic factor in mental life acts as a powerful disintegrating agent. Consider the case of a child who has learnt to write, and study the adaptations which follow as a consequence:—

When his studies commenced, he learnt that he must hold the pen in a certain position if he wished to write with ease, that the arm should not be placed as the reïless fancy prompted, and the like. He knew, broadly speaking, why he did things and how he did them. This knowledge of the how and the why of the process was doomed from the beginning. Gradually losing his interest in writing as such, having no longer any need to refer to that knowledge, and being eager to acquire other habits, he slowly forgets the how and the why. At first there was a bond of time and order; now all ties are gone. He cannot tell relationship, time, or succession. Each point is recollected independently of every other point. He cannot even indicate the *what*, though he knows what to do. The *what* has departed as a notion, and exists as a remembered act. As the child progressed there was no need to recollect the *what*, the *how*, the *why*, or any other system of relationships, and so these are forgotten. We detect here no substituted, transformed, or added constituent, only certain once existing factors have been removed. All that could be dispensed with has been cast aside.

Again:

If we are considerably interested in one thing, we cannot spare much interest for another thing at the same time. Thus there is a constant tendency for thoughts, as with animals in congested areas, to drive each other out of existence.

Suppose a man thinks that it would be best to dismiss certain impracticable thoughts immediately they occur, by turning his attention into other channels. An opportunity arrives, he remembers his resolution, and carries it into effect. After a period of practice the resolution is forgotten or not referred to; but whenever anything impracticable suggests itself he dismisses it immediately. The resolution forms now no link between the objectionable thought and the act of dismissal. As that thought appears, so it is thrust back. There may be, after a time, entire ignorance that certain thoughts are dismissed. The man may, *e.g.*, either deny that such is the fact, or he may give some plausible, but inaccurate explanation.¹

Imagine now this process to begin from infancy, and to be carried up and on through life, and it will be evident that human thought is essentially irrational, except at a very few points

¹ G. Spiller, *The Mind of Man*, pp. 96, 95, 116.

where the irrationality is less marked. Naturally, too, as we advance in age and grow in wisdom we become more and more irrational, since we employ more and more aids and means whose intent eventually escapes us wholly or in great measure. Habit grows out of habit until we find a vast congeries of habits, practically each modified by each in a composite direction difficult to detect. Moreover, the irrationality is magnified, because unpremeditated and piecemeal adaptations play, apart even from feelings and sentiments, a conspicuous part in the process of mental growth.

The conclusion is, accordingly, inevitable that an absolutist and atomist logic is impossible, for the reason that the human mind is relativist and organic in structure. Our memory is radically faulty, and our many urging desires add to the disorder by annihilating almost everything of an explanatory or rational nature. Normally we do not act, therefore, in conformity with reason; but in agreement with character, *i.e.*, in accordance with a mass of more or less interconnected habits.

II.—THOUGHT AS A PAN-HUMAN PRODUCT.

§ 10. Were this all, we might conceivably recover most of the threads which connect our mental life at every stage, by preserving faithful and complete accounts of what happens to a particular human being from infancy to maturity. In this way we should ultimately recognise the *raison d'être* of thought and understand ourselves. Yet, granted that we could reduce to calculable terms our instincts and our emotions, and granted that we could follow the super-chemistry of thought in the infant and the young child, we should not really have advanced far, for thought is inter-individual and inter-social, and develops through the ages, from primitive times forward. Our imaginary observer would be obliged therefore not only to follow the life of one individual, but the life of the whole of humanity from ape-hood upwards, and he would notice that each generation transmits to its successor a bulkier and further metamorphosed bundle of habits—in the form of records, traditions, customs, and manners—even more irrational or incomplete than those passed on by one moment to another in the history of the individual.

III.—THE MAN OF GENIUS.

§ 11. If towering geniuses existed who revolutionise the whole world of thought in their time, as the popular imagination is fond of surmising, much might be effected to re-form the trend of life on the high plane of reason by learning how their mind functions. Such geniuses, however, belong to the realm of fables.¹ The fancy evolves these by attributing to them, on

¹ For one of many examples of the deep indebtedness of our leading thinkers, see "A Commemoration of Auguste Comte", by H. Gordon Jones.

the one hand, the work of generations, and by ignoring, on the other hand, the virtually infinite mass of human reason which obtains outside their sphere of activity. Men are very small indeed, compared to Man. Myriads of so-called men of genius could not have advanced us as far as plodding humanity has actually done. It would be, therefore, idle to hope much from a study of genius, for the roots of knowledge do not lie there. The very vocabulary which the man of genius must employ almost completely dominates and controls his thought, for therein are embodied innumerable discriminations and the generalisations accumulated by mankind, both as regards objects and methods, positively binding him as to the broad road which he is to tread. Consequently, for example, such terms as Conception, Observation, Comparison, Abstraction, Generalisation, Definition, are accepted by thinkers from the past, and are interpreted primarily according to traditional conventions. To learn these terms conscientiously by heart will no more lead to the appropriate actions than the committing to memory of any series of undeciphered hieroglyphics. And when we proceed a step farther and define what we mean, say, by Observing, we effect this with the help of other symbolic terms, which equally await interpretation by a fresh set of terms, and so on *ad indéfinitem*. We are constrained hence to assume that the words we employ reflect certain actions or states, and, given an imperfect memory, the difficulty of correct interpretation becomes evident, especially when we remember that from generation to generation actions and states not only vary sensibly, but often conspicuously, to the extent of acquiring a wholly different and even contrary purport and connotation. The growth of languages admirably illustrates this profound socio-historic influence on thought, determined as this growth is by new discoveries, inventions, ways, experiences, errors, and prepossessions. And inasmuch as the task is principally humanity's and not that of any individual, it follows that the man of alleged genius is also a creature of habit, and is almost completely dependent for proficiency in thinking on the scientific methods very gradually discovered by the race.¹

in the *Positivist Review*, Sept. 1st, 1913, where it is shown that Comte's fundamental conceptions were not, strictly speaking, his own. Comte illustrates in this respect the rule. For a detailed refutation of the genius theory see the present author's forthcoming work, *The Distinctive Nature of Man*.

"The popular mind spares itself effort by crediting the house to the man who lays the last tile and allowing his co-workers to drop out of view. . . . The resolving of human achievement into contributions of tens of thousands innovating individuals has, therefore, little in common with the theory of progress which gives the glory to a few Great Men." (E. A. Ross, *Foundations of Sociology*, 1905, pp. 227-228.)

¹ Numerous illustrations in support of our contention in regard to the true place of the man of genius will be found scattered throughout this volume. (See Index, under Genius.)

IV.—CONCLUSION.

§ 12. Seeing that the struggle for existence among ideas in individuals and generations tends to eliminate everything that is superfluous in thought and conduct, all that is merely explanatory is of necessity forgotten, especially having regard to the imperfection of our memory. Consequently the individual cannot possibly think rationally or in accordance with absolutist standards. Since, moreover, culture is a pan-human and progressive product, and its assimilation is mostly determined by capricious circumstances, we readily understand the egregious blunders of the child and the haphazard generalisations and explanations of the scientifically untrained adult. Nay more, we discern now that though the modern student of science is guided no doubt by more efficacious rules for the conduct of particular enquiries, these rules, if we take into consideration the whole sphere of thought, resemble oases in an illimitable desert, or tiny islands in the ocean. For this reason also those who are most distinguished are under the heaviest obligation to the methodological legacy of the ages. Correct and methodical thinking of a general character implies manifestly a special procedure which no intelligence can adequately apply, save on the basis of an appropriate methodology which has been scientifically abstracted from the most successful practice of men of science, which practice is itself the outcome of mankind's growing and clarifying experience.

A scientific methodology is therefore a *sine qua non* for rapid progress. At the same time, since it is not a question of applying new or rare mental powers in methodology any more than, say, in machine construction, there is no reason why such a theory of efficiency, pedagogically inculcated, should present in the process of acquisition more obstacles than the many obscure and unconnected rules which precariously pilot men's cogitations in our age. Hence a high level of average thinking should follow a completer systematisation of contemporary scientific methods of enquiry.

We shall conclude Part I by tracing, agreeably to the relativist conception verified in the preceding five Sections, the historic process of methodological theory as crystallised in the works of the historically most prominent methodologists.

SECTION VI.—THE PROGRESS OF METHODOLOGICAL THEORY.

§ 13. The gem of untold value in Aristotle's *Organon* is undoubtedly his syllogism. The naming of its several parts, its figures and moods, together with the establishment of the nature of a good definition and a proper classification, the determination of kinds of causes and of categories, an exposure

of fallacies¹, and analogous sections, practically shrink into insignificance before the syllogism itself. Here we are offered a formal and infallible method of testing a proposition, or at least certain propositions, and this represents, therefore, a discovery fraught with the utmost consequence in the realm of ratiocination. Nor is there a doubt that Aristotle's syllogism has entered the very marrow of social thought, and that even his uncompromising opponents are deeply indebted to him. It must be said also that many sophisms would never appear plausible if men applied the syllogism more generally.

The syllogism constitutes a formal method of testing the soundness of a statement by showing how it necessarily follows from certain accepted premises; it does not represent the whole of the reasoning process. Not only does it disregard the fact that all but the rarest conclusions deal with probability and not with certainty; but unless employed as a merely mechanical test of the reasoning process, it is meaningless. If any one had greeted a neighbour of Socrates with "All men are mortal, Socrates is a man, Therefore Socrates is mortal!" this neighbour would have been at once concerned about the questioner's sanity. He would have protested: "Have I asked you whether all men are mortal, or had you any reason to believe that I was interested in man's mortality?" and he might have added: "Why should there be a reference to Socrates; why do you draw a conclusion; and why should you have launched the three sentences at my head at all?" Even the proposer of the above syllogism would meet it with an uneasy note of interrogation if it welled up in his mind *à propos* of nothing in particular. Manifestly, the syllogism presupposes the desire to know whether Socrates is mortal, and this desire arises again out of an extensive succession of interrelated and mostly undetermined situations which cannot be reduced to a chain of syllogisms, as will be evident from the arguments advanced in the preceding Section. When we further consider, also in consonance with the last Section, that knowledge is commonly acquired in a fortuitous fashion, and that habits and the associative processes provide many short routes to a conclusion, it should be readily granted that the syllogism does not reflect the normal process of reflective thought. In pure reason, seeing a mushroom, I argue: "All mushrooms are good to eat; this is a mushroom; therefore it is good to eat"; but, in practice, I feel hungry, I chance to see a mushroom in the wood where I am strolling, and, without thinking, I take it and eat it, as

¹ The art of detecting fallacies is rendered almost superfluous when our primary concern is with the facts underlying propositions. Under such conditions terminological difficulties are reduced to a minimum. On the subject of fallacies, Prof. Sidgwick's special work (*Fallacies*, London, 1883) may be consulted with advantage. See also Mill's luminous and unconventional exposition of the subject in Book 5 of his *Logic*.

I have taken and eaten mushrooms on similar occasions. The syllogism, in this particular instance, is altogether wanting. The actual and the ideal reasoning processes differ, therefore, fundamentally as a rule.

The specific value of the syllogism lies in its being a touchstone for dogmatic statements. Where, however, statements are undogmatic, its value is reduced almost to zero. If we said "It is probable that all men are mortal; Socrates is perhaps to be classed as a man", we should be scarcely warranted to state dogmatically more than that "there is an indeterminable probability that Socrates is mortal". It is true that we possess relatively excellent reasons for believing that every human being, born in any land on the earth, and at any period up to some 120 years ago, has died, and that the men of the present day and those of the comparatively near future are also eminently likely to die; but dogmatically we are not entitled to state in our age that mortality is a permanent attribute of every human being as such.¹ We are dealing here with a purely empirical generalisation. Accordingly, it is not certain, as the school syllogism appears to prove, that Socrates is mortal, save by arbitrarily assuming that all men are mortal. Even the leading facts of gravitation and evolution have nothing absolute about them when regarded in the light of the eternities, and the laws of mathematics and of thought have had their alleged immutable character challenged; and, besides, who knows what the science of to-morrow will be able to accomplish in the matter of extending man's term of life?² From this it follows that indifferent use can be made as yet of the syllogism as an instrument of science, and this view is strengthened when

¹ The most securely established generalisations in science frequently have exceptions: "The presence of chlorophyll, which had always been associated only with plant organisms, was detected by Max Schultze in 1851 in the animals *Hydra* and *Vortex*, and later on by Ray Lankester in *Spongilla* and by Patrick Geddes in some Turbellarian worms." (*Encycl. Britannica*, 11th edition, article "Parasitism", by P. C. Mitchell, p. 794.) And yet we must remember that "in many cases where animals of some size have a green colour and are apparently able to subsist on simple chemical substances, this appearance has been shown to be due to the fact that their bodies are the homes of multitudes of minute plants, which grow in them and give them their colour by shining through the more or less transparent substance of the body, but which sooner or later are digested by the animals in which they live and serve as their food". (E. W. McBride, *Zoology*, 1911(?), p. 8.)

Again. "During the last ten years living larvæ have been produced by chemical agencies from the unfertilised eggs of sea-urchins, star-fish, holothurians, and a number of annelids and molluscs." (Article by Jacques Loeb on an "Experimental Study of the Influence of Environment on Animals", in *Darwin and Modern Science*, ed. by A. C. Seward, 1909, p. 251.)

It should be remembered also that whilst some of the Ephemeridæ live only a few hours, certain species of trees have a life-span of several thousand years. Nor should we forget that, barring accident, the protozoa are considered immortal, and that this is almost certainly true of the reproductive germs.

² E. Metchnikoff, *The Prolongation of Life*, 1910.

we consider that the overwhelming majority of syllogisms in books on logic are fatuously trivial, mostly confirming what no one would ever think worthy of contesting.

Psychologically the syllogism may be said to depend on the emergence of a doubt concerning the validity of a certain plausible statement; on the consequent suggestion that this doubt would be removed if the statement could be shown to be involved in a more comprehensive and indubitable statement; and, lastly, after reflection, on the more formal setting out of the more comprehensive statement if any such can be found, the middle or mediating statement, and, in the form of a conclusion, the statement to be proved. The process might be expressed by some such reasoning: "You desired to have it proved that Socrates is mortal. Well, then, if you are able to agree that all men are mortal, and if you can further agree that Socrates is a man, it will follow of necessity that Socrates, being a man, is mortal. Here is, therefore, the proof which you were solicitous to obtain." That is, by employing an ingenious formula, we convert a confused into a clear thought. To avoid that the syllogism should be question-begging, it might formally run: "Problem: Desired to prove that Socrates is mortal. Proof: If (it be agreed that) all men are mortal, and if (it be agreed that) Socrates is a man, then (it must be agreed that) Socrates is mortal. The proposition that Socrates is mortal is thus proved (for him who agrees to the two conditional statements)."^{1 2}

§ 14. In early days, when scarcely anything was known of the vast world, and the vast world seemed very small and like an open book or rather pamphlet,³ men demanded *verbal clearness and consistency in statements* as tests which are readily appli-

¹ A well known university professor writes to the author: "I seriously believe that the slow progress of science is largely due to the deterioration of the scientific powers of the young mind in this long enduring official logic—oscillating between syllogistic platitudes and ingenious fallacy-hunting, until all real interest in and inquiry into nature and life are lost sight of, and the patient is ready to go on to the bar, or some kindred destination."

² Before Mill, logic was almost universally identified with deductive or syllogistic logic. "The rules of logic have nothing to do with the truth or falsity of the premises, but merely teach us to decide (not whether the premises are fairly laid down, but) whether the conclusion follows fairly from the premises or not." (Whately, *Elements of Logic*, 1827, p. 210.) The tendency is now to identify logic with the analysis of the nature of judgments. "Logik ist Urteilslehre", says Windelband. (*Logik*, p. 189.) Algebraic or symbolic logic does not concern us in this volume, inasmuch as according to one of its exponents, "natural science is not immediately furthered by the rules of the logical calculus". (A. T. Shearman, "Some Controverted Points in Symbolic Logic", in *Proceedings of the Aristotelian Society*, 1905, p. 99.) Earlier classics on the subject are: S. Boole, *An Investigation of the Laws of Thought*, and De Morgan, *Formal Logic*. In *Principia Mathematica*, Whitehead and Russell apply the logical calculus to mathematics.

³ To appreciate the remarkable contrast between pre-scientific naïveté and scientific profundity, let the reader compare John Ruskin's conception of the origin of Alpine and English scenery in his *Fronde Agrestes*, with Lord

cable under such inexacting conditions.¹ When, however, the immeasurable expanse and complexity of the Universe came to be suspected, verbalism lost its hold, and men turned *from words to things*, transferring the emphasis from proofs to methods of discovery.² As an outcome of this advance we have Bacon's *Novum Organum*, an attempt mainly to facilitate the collection of flawless major premises. Unfortunately, Bacon, unlike Aristotle, never exhausted and systematised his central thought. The multitude of his prerogatives constitute tricks of a trade, not a systematic procedure, and the deadly denunciation of the speculative method possesses after all only negative value. Instead of a system, we find many excellent hints and one example. From this example—the method employed in the discovery of the nature of heat—we learn most. Bacon bids us turn to the facts, and cease drawing conclusions from propositions which have not been established inductively. He insists that “all interpretation of nature commences with the senses, and leads from the perceptions of the senses by a straight, regular, and guarded path to the perceptions of the understanding”. (*Novum Organum*, bk. 2, 38.) Observation should be virtually exhaustive in regard to variety, so far as classes of relevant facts are concerned.³ We are to observe; we are to move step by step, and not to aim directly at distant conclusions; we are to watch for the presence of a quality (“Instances agreeing in the nature of heat”) or its absence under similar circumstances (“Instances in proximity where the nature of heat is absent”); we are to examine the degree of the presence of a quality (“Table of degrees or comparison in heat”); we are systematically to exclude from the three preceding collections what is immaterial to the issue (“Exclusion or rejection of natures from the form of heat”); and, finally, we are to formulate a double conclusion, theoretical and practical (First and Second Vintage). The purpose of science, on the

Avebury's *The Scenery of Switzerland* and *The Scenery of England*. The pettiness of the former and the grandeur of the latter view well exemplify what humanity has gained by an objective study of nature.

¹ “Generalisations approximately true, or possessing a certain degree of probability; hypotheses held loosely until verification is possible . . . , of these Aristotle did not treat.” (Naden, *Induction and Deduction*, p. 24.)

² Modern logicians are reconciled to modern needs. “Applied logic”, Lotze tells us, “must . . . sacrifice the love of systematisation to considerations of utility, and select what the experience of science has so far shown to be important and fruitful.” (*Logic*, vol. 1, p. 11.)

“The mandate issued to the age of Plato and Aristotle was *Bring your beliefs into harmony with one another*. . . . The mandate of the Mediæval Spirit was *Bring your beliefs into harmony with dogma*. . . . Then . . . a new spirit was roused, the mandate of which was, *Bring your beliefs into harmony with facts*.” (W. Minto, *Logic, Inductive and Deductive*, 1893, p. 243.) Arthur Lynch, in his *Psychology: A New System*, 1912, part 1, ch. 2, deals at some length with modern scientific methods.

³ To this principle he remained faithful in the many investigations which he undertook.

theoretical side, Bacon defines to be "the knowledge of causes and secret motions of things" (*New Atlantis*); or as he expresses this in another place: "the true and lawful goal of the sciences is none other than this: that human life be endowed with new discoveries and powers". (*Novum Organum*, bk. 1, 81.)

There is a popular proverb to the effect that "the proof of the pudding lies in the eating", and one would be justified in maintaining that the proof of a method lies in its results. Now in the above example Bacon reaches the conclusion that "heat is a motion, expansive, restrained, and acting in its strife upon the smaller particles of bodies" (bk. 2, 20), and modern science concurs that heat is a mode of motion, that it is expansive, and is concerned with the molecules of which bodies are composed.¹ All circumstances considered, this is an epoch-making discovery. To arrive at this result Bacon examines exhaustively classes of instances where heat appears as well as the degree of the heat, and where it is absent under circumstances corresponding to those where heat is present. He then excludes all factors not common to every instance of heat, formulates a careful definition embodying the results obtained, and draws certain deductions.

The virtue of this method is obvious. It involves a comprehensive and cautious general survey of the facts and a systematic elimination of everything that is irrelevant to the matter in hand—a proceeding which, if universally imitated, would invalidate partially or wholly most of the conclusions reached in the more strictly human sciences, and would materially enrich the established physical and biological sciences where, as a rule, only prominent thinkers follow this direction. It is the very opposite of the all too common practice of cursory observation, chance generalisation, and casual verification. Up to the present this central method of Bacon's is the only one which has striven to arrive at truth through a series of synthetically connected links instead of through some jumpy, vague, or disconnected mode of procedure, and may therefore be said still to be without a peer or even rival. Granted that it is only applicable to less obscure problems of a general character, that it requires subsidiary aids as Bacon concedes,² and that its rigour may be somewhat relaxed under relatively favourable circumstances where many relevant facts are scientifically established, there is still enormous scope for its use. The method seems to be in place in the cultural sciences generally, and in all others so far as the facts are open to inspection. Reluctance to be bound by exacting rules, convenience in following others

¹ Compare John Tyndall, *Heat as a Mode of Motion*, 1887, and J. Clerk Maxwell, *Theory of Heat*, 1894.

² In his "histories" there is no clear indication of the employment of subsidiary aids, and yet the presence of such aids is the ultimate criterion of a complete methodology.

sheepishly, an adventurous delight in entrusting the bark of science to good fortune, and a desire of reaching conclusions rapidly, may have much to do with the prevalent neglect of consciously employing, even in part, Bacon's method-in-chief. Methodologists, however, may in time return to it, seeing that they, through John Stuart Mill's Canons, have adopted, almost in its entirety, the skeleton of the method, only separating it into independent parts and neglecting the subsequent processes of exact definition of the comprehensive conclusion or statement arrived at and the theoretical and practical deductions which are to be drawn therefrom. Indirectly Bacon thus continues to hold the field, and the sole alternative to adopting his comprehensive and synthetic method of investigation is to substitute an equally comprehensive and synthetic method of a more modern character. It is inconceivable that educated men and women will much longer tolerate the farrago of blurred and inarticulated half-rules which now passes under the name of methodology. They will ask that we either return to Bacon, or that we transcend him through a method even more comprehensive than his. (See Conclusion 2 for such a method.)

As we have seen, exception could hardly be taken to the example analysed by Bacon, were it not that it is only an example, and that an example which is not succeeded by a number of other examples and a series of conclusions, is liable to be interpreted in more ways than one, and cannot illustrate every possible case. The nature of observation, experimentation, generalisation, definition, deduction, and the process of forming hypotheses as well as the mode of verifying them, in conjunction with sundry other matters, including the categories into which phenomena can be profitably divided, should have been determined as precisely as possible by Bacon; and probably if his life had not been abruptly terminated through excessive scientific zeal, and if he had not attempted to achieve what is beyond the powers of an isolated individual, he might have given his *Novum Organum* a systematic form.

Bacon, as we shall endeavour to show in the sequel, was substantially right in respect of the method of science. His numerous allusions to experiments undertaken by himself in order to verify some conjecture, demonstrate his respect for the experimental method, whilst his fierce attacks on the deductive mode of enquiry are really directed against utilising propositions which are not based on a study of facts and are not succeeded by scrupulous verification. Even an uncompromising critic like Miss Naden admits that "his error is not the rejection, but the postponement, of deduction". (*Induction and Deduction*, p. 45.)¹

¹ "My directions for the interpretation of nature embrace two generic divisions: the one, how to educe and form axioms from experience; the other, how to deduce and derive new experiments from axioms." (*Novum Organum*, bk. 2, 10.)

When we remember that Bacon wrote at the very dawn of modern science, that the few experimenters of his day were scarcely distinguishable in the swarm of alchemists, astrologers, and magicians, and that even the terminology at his disposal was unspeakably confusing, we shall not be surprised at his numerous misapprehensions and the comparative crudity which he displays. The admiration lavished by Herschel on Bacon as the father of inductive logic is richly deserved: "It is to our immortal countryman Bacon that we owe the broad announcement of this grand and fertile principle, and the development of the idea, that the whole of natural philosophy consists entirely of a series of inductive generalisations, commencing with the most circumstantially stated particulars, and carried up to universal laws, or axioms, which comprehend in their statements every subordinate degree of generality, and of a corresponding series of inverted reasoning from generals to particulars, by which these axioms are traced back into their remote consequences, and all particular propositions deduced from them; as well those by whose immediate consideration we rose to our discovery, as those of which we had no previous knowledge." (*Discourse*, [96].) Here we shall leave Bacon.

§ 15. Reactions, if not inevitable, are common. Thus it is not surprising that attempts should have been made to remove the laurel wreath from Francis Bacon's brow and place it on Roger Bacon's. This method of referring back systems of thought to some real or imaginary precursor has its dangers, for the process permits of indefinite extension. Thus we read concerning Roger Bacon: "Bacon hatte seine philosophische Anregung hauptsächlich aus den Arabern geschöpft." (Karl Werner, *Die Kosmologie und allgemeine Naturlehre des Roger Bacon*, Vienna, 1879, p. 5.) Nor was he inclined to be heretical in theology: "Bacon accepted the dominant mediæval convictions: the entire truth of scripture; the absolute validity of the revealed religion, with its dogmatic formulation; also (to his detriment) the universally prevailing view that the end of all the sciences is to serve their queen, theology." (H. O. Taylor, *The Mediæval Mind*, vol. 2, 1919, p. 515.) As for his ethics: "C'est à Aristote surtout que sont empruntées la plupart des idées de Bacon sur la vertu." (Emile Charles, *Roger Bacon*, 1861, p. 257.) In respect of his Optics, this was "based upon the great work of Alhazen" (J. H. Bridges, *Life and Work of Roger Bacon*, 1914, p. 24); "Mathematics in Bacon's mind was little more than astronomy" (D. E. Smith, in "On the place of Roger Bacon in the History of Mathematics", in *Roger Bacon*, ed. by A. G. Little, 1914, p. 174); and his experiments with burning glasses, etc., were repetitions of well-known attempts. (A. G. Little, *Part of the Opus Tertium of Roger Bacon*, 1912, p. xxxvii.) So also Charles informs us in the course of his erudite investigation that "la plupart des découvertes de Bacon en optique ne sont pas plus réelles que les précédentes" (*op. cit.*, p. 302), that is, those relating to bridges, gunpowder, and the like. And concerning his scientific equipment we learn that Bacon was "trained in scientific method by Grosseteste and other members of the English mathematical school". (Bridges, *op. cit.*, p. 24.) Indeed, nothing more fantastic and untrustworthy can be imagined in our age, than the mediæval science of Roger Bacon borrowed from his contemporaries, as exemplified, for instance, in *The Mirror of Alchemy*, etc., a translation of which treatises appeared in 1597; in *The Cure of Old Age and Preservation of Youth*, ed. 1683; or in the third part of Friedrich Roth-Scholtzen's *Deutsches Theatrum Chemicum*, part 3, 1732.

Any such care on experiments as Francis Bacon bestows, appears to be practically absent in Roger Bacon. His method was apparently urged in self-defence of his views, rather than as an expression of his desire to elaborate a methodology, and his conception of "experience" was, because of his age, primitive in the extreme, and approached therefore that of the scienceless "practical man" rather than that of the modern savant. This appears to be borne out by Mr. Lynn Thorndike's *Roger Bacon and the Experimental Method in the Middle Ages*: "The collection of facts was another engrossing pursuit [of the Middle Ages], as the voluminous mediæval encyclopedias testify; there was keen curiosity about the things of this world." (P. 277.) "Bacon's discussion of experimental science, on its positive side, amounts to little more than a recognition of experience as a criterion of truth and promulgation of the phrase 'experimental science'." (P. 283.) And Thorndike sums up: "On the whole, one rather gets the impression that the experimental method that Bacon pleads for, as if it were a novelty, is already assumed by other writers as a well-established method." (P. 290.) Having stated so much in criticism, we quote with pleasure a laudatory passage relating to Roger Bacon's conception of method. Robert Adamson, in his *Roger Bacon* (Manchester, 1876, pp. 32-33) concludes: "So far as I can gather, the ideal natural philosophy, according to Roger Bacon, consisted of the following steps: (1) Application of mathematics to the determination of the simple laws of force; (2) observation and comparison of the complex phenomena of nature; (3) deductive application of the elementary mathematical principles, the laws of force, to the observed phenomena; (4) experimental verification of the results deductively obtained."

According to Charles, whose work is virtually exhaustive, Roger Bacon recognised three ways of reaching truth—"l'autorité, qui ne peut produire que la loi, et d'ailleurs doit se justifier aux yeux de la raison; le raisonnement, dont les conclusions les plus certaines laissent à désirer, si on ne les vérifie pas; et enfin l'expérience, qui se suffit à elle-même". (P. 112.) The only passage Charles quotes from Roger Bacon refers to "l'autorité indigne et fragile, l'empire de la routine, la stupidité du vulgaire, l'amour-propre des savants, qui leur fait cacher leur ignorance sous l'étalage d'une science apparente" (p. 99); or in English: "the example of frail and unworthy authority, long-established custom, the sense of the ignorant crowd, and the hiding of one's own ignorance under the shadow of wisdom". (H. O. Taylor, *op. cit.*, p. 524.) In fact, Roger Bacon did not pass beyond methodological generalities: "For rules of induction, even faintly analogous to those of the *Novum Organum*, the student of the *Opus Magnum* will seek in vain" (J. H. Bridges, *op. cit.*, p. 160), a dictum which is by no means invalidated by the numerous quotations in J.V. Marmery's *Progress of Science*, 1895.

Perhaps the following passage from Roger Bacon approaches most nearly the methodological spirit of modern times: "The true method of research, says Bacon in the *Compendium studii*, 'is to study first what properly comes first in any science, the easier before the more difficult, the general before the particular, the less before the greater. The student's business should lie in chosen and useful topics, because life is short; and these should be set forth with clearness and certitude, which is impossible without *experientia*. Because, although we know through three means, authority, reason, and *experientia*, yet authority is not wise unless its reason be given, nor does it give knowledge, but belief. We believe, but do not know, from authority. Nor can reason distinguish sophistry from demonstration, unless we know that the conclusion is attested by facts. Yet the fruits of study are insignificant at the present time, and the secret and great matters of wisdom are unknown to the crowd of students.'" (H. O. Taylor, *op. cit.*, p. 538.)

To sum up, Roger Bacon may be considered to have been among the advance guard of his time, as Francis Bacon was of his. The elaboration of a sound methodology was scarcely feasible in Francis Bacon's day when

the sun of science had just risen; it was altogether impossible in Roger Bacon's period when pioneers were groping to escape from the pitch-dark night and superstition of the early Middle Ages. (See also J. E. Sandys, *Roger Bacon*, 1914; and S. Vogl, *Die Physik Roger Bacos*, 1906.)

§ 16. Descartes' method tends to lure us away from outward nature, and lays the stress on speculatively obtained propositions or general principles. The great desideratum, according to the illustrious French philosopher, is to possess clear and distinct¹ ideas, and to reject everything which does not harmonise with these. Pursuing this method, we shall, he assures us, discover the fundamentals of existence, and from them all the other facts will be deducible. The vital step to take is "to divest oneself of preconceptions and study propositions exhaustively and impartially, making as complete a survey of our material as possible, and simplifying our problems to the uttermost. Induction is here the handmaid of deduction, and the aim is to discover, right at the threshold, the highest generalities, and utilise these for deductive ends. (*Discours sur la méthode*, I, 19.) Leaving aside his solid contributions to mathematics, Descartes' method has exerted but a feeble influence on scientific progress, for the sufficient reason that terms such as Clear and Distinct, on which he places such emphasis, do not admit of exact definition, that trains of reasoning are even more dangerous to rely on than the perceptions of the senses, and because he preferred reasoning from speculative propositions rather than objective study, seeking in this way to apply pre-scientific methods in a growingly scientific age.² Just as Bacon for all intents and purposes first developed to a high degree the inductive method and over-stressed it, so Descartes was virtually the first to emphasise the signal value of deductive and mathematical treatment without appreciating their severe limitations. In connection both with Francis Bacon and Descartes it may not be amiss to notice that methodology formed their principal life-interest.

Bertrand Russell, in his *Our Knowledge of the External World as a Field for Scientific Method in Philosophy*, 1914, appears to aim at reviving the Cartesian point of view: "The nature of philosophic analysis, as illustrated in our previous lectures, can now be stated in general terms. We start from a body of common knowledge, which constitutes our data. On examination, the data are found to be complex, rather vague, and largely interdependent logically. By analysis we reduce them to propositions which are as nearly as possible simple and precise, and we arrange them in deductive chains, in which a certain number of initial propositions form a logical guarantee for all the rest. These initial propositions are *premises* for the body of knowledge in question. Premises are thus quite different from data—they are simpler, more precise, and less affected

¹ Locke preferred "determinate or determined". (*Essay on the Human Understanding*, Epistle to the Reader.)

² Jevons says in this connection: "Descartes and Leibniz sometimes adopted hypothetical reasoning to the exclusion of experimental verification." (*Principles of Science*, p. 508.)

with logical redundancy. If the work of analysis has been performed completely, they will be wholly free from logical redundancy, wholly precise, and as simple as is logically compatible with their leading to the given body of knowledge. The discovery of these premisses belongs to philosophy; but the work of deducing the body of common knowledge from them belongs to mathematics, if 'mathematics' is interpreted in a somewhat liberal sense." (P. 211.)

§ 17. The grandiose and historically recognised¹ attempts to unravel the problems of the scientific method have been historically so few that we must pass at one bound to John Stuart Mill, whose inductive logic is the first and, up to the present, the last truly systematic attempt to deal with the methodology of science, which has challenged the attention of the modern world. That he has to some extent succeeded is proven by the universal respect which his *Logic* still commands, and by the fact that since his time books on logic pay at least lip homage to inductive procedure. (See Conclusion 1.) From the point of view of method, his cardinal achievement is no doubt the list of scientific Canons which he compiled—the methods of agreement, difference, agreement and difference, residue, and concomitant variation. These Canons do not possess the rigidity and completeness of the syllogism, and have therefore been much criticised; but they form nevertheless a monumental landmark in the history of methodology. They also agree in intention with the syllogism in that their object is to obtain indisputable proofs;² and perhaps if all the Canons could be applied, and were properly defined and respected, nothing but what is rigidly true would be accepted.

Most of the praise bestowed on Mill's Canons should properly be transferred to Bacon who, it is persistently asserted, had no clear insight into the method of science. Bacon's famous example of the investigation into the nature of heat explicitly involves the Canons³, with the exception of the admittedly least important joint method of agreement and difference, which are now identified with Mill. The earlier methodologist formulates, as we have seen, rules of affirmative and negative instances, of concomitant variations and exclusions which, save for the immaterial exception mentioned, are one with Mill's Canons; only Mill's Canons are more definitely conceived, though not articulated as those of Bacon are. On the other hand, by ignoring the need, as pointed out by Bacon, for exhaustive

¹ We say "historically recognised", for, *e.g.*, not a few would consider Sir John Herschel's presentation of methodology in his *Discourse* as profounder than that to be found in John Stuart Mill's *Logic*.

² "It is with proof, as such, that logic is principally concerned." (Mill, *Logic*, bk. 3, ch. 9, § 6.) "The appropriate problem of logic [is] the estimation of evidence." (*Ibid.*, bk. 4, ch. 1, § 1.) "The business of Inductive Logic is to provide rules and models (such as the syllogism and its rules are for ratiocination) to which, if inductive arguments conform, those arguments are conclusive, and not otherwise." (*Ibid.*, bk. 3, ch. 9, § 6.) Bain (*Logic*, vol. 2, p. 49) largely agrees with this: "Proof, more than discovery, is the end of logic."

³ "The principles on which [the Instances in Bacon] are arranged in Tables bear a close analogy to the principles on which the Canons [of Mill] are constructed." (Fowler, *Logic*, vol. 2, p. 211.)

examination and verification, Mill almost annihilated the virtues of his Canons, and practically cut himself off from contact with actual scientific work.

Moreover, a study of Herschel's brilliant *Preliminary Discourse*, fervently admired by Charles Darwin, further reduces Mill's claims, for in the rules suggested by this immediate forerunner of Mill, Mill's whole set of Canons, with almost all its neatness, may be found approximately in Mill's words. This is a beautiful illustration of our contention that truth is progressive and represents a growing product of collective endeavour. Mill, in his *Autobiography*, informs us that, "under the impulse given me by the thoughts excited by Dr. Whewell, I read again Sir John Herschel's *Discourse on the Study of Natural Philosophy*, and I was able to measure the progress my mind had made, by the great help I now found in this work". (Ch. 6.) Herschel [145.] submits the following "general rules for guiding and facilitating our search, among a great mass of assembled facts", for their common cause: "(1) Invariable connection, and, in particular, invariable antecedence of the cause and consequence of the effect, unless prevented by some counteracting cause. (2) Invariable negation of the effect with absence of the cause, unless some other cause be capable of producing the same effect. (3) Increase or diminution of the effect, with the increased or diminished intensity of the cause, in cases which admit of increase and diminution. (4) Proportionality of the effect to its cause in all cases of direct unimpeded action. (5) Reversal of the effect with that of the cause." In this chapter Herschel speaks of "Agreement", "Concomitant circumstances", and "Residual phenomena", and also judiciously illustrates the Method of Difference. With his noted candour Mill admits his debt to Herschel, saying that in this scholar's *Discourse*, "of all books which I have met with, the four methods of induction are distinctly recognised". (*Logic*, bk. 3, ch. 9, § 3.)

The following are Mill's Canons (bk. 3, ch. 8):—

First Canon.—If two or more instances of the phenomenon under investigation have only one circumstance in common, the circumstance in which alone all the instances agree is the cause (or effect) of the given phenomenon. (See Herschel, *Discourse*, [146-148.])¹

Second Canon.—If an instance in which the phenomenon under investigation occurs, and an instance in which it does not occur, have every circumstance in common, save one, that one occurring only in the former, the circumstance in which alone the two instances differ is the effect, or the cause, or an indispensable part of the cause, of the phenomenon. (See Herschel, *Discourse*, [156.])¹

Third Canon.—If two or more instances in which the phenomenon occurs have only one circumstance in common, while two or more instances in which it does not occur have nothing in common except the absence of that circumstance, the circumstance in which alone the two sets of instances differ is the effect, or the cause, or an indispensable part of the cause, of the phenomenon.

Fourth Canon.—Subduct from any phenomenon such part as is known by previous inductions to be the effect of certain antecedents, and the residue of the phenomenon is the effect of the remaining antecedents. (See Herschel, *Discourse*, [158.])¹

Fifth Canon.—Whatever phenomenon varies in any manner whenever another phenomenon varies in some particular manner, is either a cause or an effect of that phenomenon, or is connected with it through some fact of causation. (See Herschel, *Discourse*, [145.])

These Canons possess at least three grave defects. In discussing the syllogism we pointed out that we are seldom in a position to possess exhaustive data or incontrovertible proof

¹ In the wording of Mill's Canons there is a remarkable similarity to Herschel's sentences.

of any matter, and from this it follows that in general scientific work the Canons could play but a small part, whilst in cultural investigations, for instance, there would be scarcely ever an opportunity of applying them. No doubt, in the manipulation of letters—*abcde*, *abcd*, *bcd*, *ca*, *dc*—we can readily detect what purports to be the common or differentiating fact, but in nature itself the component elements in a problem are unfortunately not lettered,¹ and certainty is, therefore, an ideal to be respectfully approached rather than to be frequently attained in experience. A good illustration of this are the many obstinate obscurities and difficulties encountered in consistently conceiving and interpreting the Periodic Law in chemistry. What is hence needed are additional Canons which shall deal with approximate truths, for only such truths are the staple product of modern science which has done once for all with the Noah's Ark world postulated by the ancients.

Scores of passages like the following could be quoted to enforce the teaching of history that certainty is attained only slowly and laboriously:—

"A good deal of evidence has been accumulated in favour of the view that the meteorological conditions of our globe exhibit a periodicity of thirty-five years—in other words, that there is a tendency for a similarity in the general run of the seasons to recur after the lapse of this interval of time. Bruckner's study of the information available regarding the variations of the water level in the Caspian Sea, first suggested this period. Russian records also contain a good deal of information regarding floods or unusual shallowness of the rivers, and the dates of their opening and closing to navigation, and a close examination of this material tended to confirm the view. Subsequently, the investigation was extended to the water levels of lakes in other parts of the world, having inland drainage, and the results were again in many instances broadly confirmatory of Bruckner's cycle. Records of the advance and recession of Alpine glaciers also supplied a certain amount of confirmation. The evidence in favour of the existence of a periodicity of thirty-five years has had to be culled, often with great labour, from historical documents in which references to meteorological phenomena are only incidental. Only by using such sources of information has it been possible to extend the inquiry over the greater part of the last two centuries. Such indirect evidence is not so satisfactory as we could wish, but the number of meteorological records which are of sufficient length to be of service in an inquiry of this sort is very small. Hann's examination of the rainfall records from Padua, Milan, and Klagenfurt, which cover the years from 1726 to 1900, has shown some indications of the reality of a period of average length of about thirty-five years. In the meteorology of the Southern hemisphere, different authors have found indications of the existence of a period of nineteen years. The records of Australia, South Africa, and South America all show suggestions of such a period, but as yet the evidence cannot be regarded as conclusive." (R. G. K. Lempfert, *Weather Science*, pp. 76-77.)

A second defect is revealed when we attempt to apply the Canons. How many times must I determine agreement before the Canon of Agreement, for example, is satisfied? Or what

¹ For an analogous criticism of Mill's alphabetic conception, see Whewell, *Philosophy of Discovery*, pp. 263, 264.

shall ensure the correctness of our observations? Is it sufficient to make one observation, or two, or five, or ten? Consider an instance. The inhabitants of Uganda suffer from sleeping sickness, and it is required to ascertain its cause. Some one submits that the Tsetse fly is answerable for the many deaths traceable to this disease. Does it, then, suffice to make one or two observations, and to note the presence of the fly in these cases? But let us idealise our example, a process not contemplated by Mill. Suppose we learn that everybody in Uganda who is suffering from sleeping sickness has been molested by a Tsetse fly, that no one who has not been so molested has the particular sickness, and that more or fewer Tsetse flies means more or less sleeping sickness, does it follow now that the Tsetse fly is the direct cause of the sleeping sickness? Now, skilful observation has shown that the cause is some species of Trypanosome which is harboured by the Tsetse fly.¹ Unless, therefore, we are absolutely sure with regard to the number of possible causes, and are certain, too, that we have observed correctly, the Canon can never be said to have been truly applied. In other words, Mill was unconscious of the impracticability of dealing with methods of proof apart from methods of discovery.

Finally, the Canons only profess to be concerned with causes. Mill, following Herschel², speaks of "the notion of cause being the root of the whole theory of induction" (*Logic*, p. 213), and of "inductive inquiry having for its object to ascertain what causes are connected with what effects" (p. 251). Yet in other places he tells us that "induction may be defined the operation of discovering and proving general propositions" (p. 186), that "induction is that operation of the mind by which we infer that what we know to be true in a particular case or cases, will be true in all cases which resemble the former in certain assignable respects" (p. 188), that "induction is a process of inference" (p. 188), and that "induction, properly so-called, . . . may, then, be summarily defined as Generalisation from Experience" (p. 200). We are confronted here with a palpable contradiction, for we may generalise static facts as we may generalise causes; but the establishment of a cause is not called a generalisation, any more than the establishment of a fact as such. Mill's Canons do not, therefore, propose any tests dealing with generalisation as such, with generalisation as to objects and causes, or with facts as such.³

¹ In certain parts of Africa the Tsetse fly is not infected, and therefore innocuous.

² Herschel, in this matter, followed Bacon, who was evidently following in others' footsteps: "It is a correct position that 'true knowledge is knowledge by causes.'" (*Novum Organum*, bk. 2, 2.)

³ A spirited attack on the Canons will be found in Bradley's *Logic*, pp. 331-342.

It is well known how scientists examine for months and years the distinctive characteristics of a substance or the influences which affect it, as is now the case with radium. Mill, on the other hand, lauded to the skies the liberal use of hypotheses, and left it to the art of education¹, as distinct from logic, to train the human mind to wrestle with the subtlety of nature and prepare men for reading its secrets—as if a fragmentary methodology were a methodology at all. "In scientific investigation," he writes, "as in all other works of human skill, the way of obtaining the end is seen as it were instinctively by some superior minds in some comparatively simple case, and is then, by judicious generalisation, adapted to the variety of complex cases." (*Logic*, bk. 6, ch. 1, § 1.) With such an almost superstitious regard for the value of instinct² or intuition matters are immensely simplified. Mill apparently never entered into the spirit of indefatigable experimentalists like Faraday, to whom it was "discomfort to reason upon data which admitted of doubt" (Tyndall, *Faraday as a Discoverer*, 1868, p. 41), nor did he consciously recognise that acknowledged scientific thinkers are as much observers as they are generalisers. If we add that Mill, agreeing in this with logicians generally, does not provide us with an adequate analysis of such terms as object, observation, hypothesis, generalisation, deduction, and verification, we shall be convinced that he did not exhaust his subject. In fact, an examination of Mill's *Logic* will show that, in the main, it presents a philosophical discussion of certain inductive principles rather than an attempt at constructing a comprehensive or systematic methodology.

We have seen that scientific thinkers grow into the methods which they happen to employ. It is consequently readily under-

¹ So Welton (*Manual of Logic*, vol. 2, p. 111): "The means of training the power of accurate observation belong to the general theory of education, not to logic."

² Mill's point of view on this matter resembles so closely that of his immediate predecessor Whewell that there appears to be adequate reason for believing that Mill was strongly and fatally influenced by him. Since Mill abstracted the substance of the material for the inductive part of his *Logic* from Whewell (*Autobiography*, ch. 6), this is not astonishing. Whewell, in his *Novum Organum Renovatum*, 1858, says little in justification of the title of his work. "An art of discovery is not possible. At each step of the investigation are needed invention, sagacity, genius—elements which no art can give." (P. v.) "Scientific discovery must ever depend upon some happy thought, of which we cannot trace the origin; some fortunate cast of intellect, rising above all rules." (P. 44.) Nevertheless he presents some scheme: "We have the following series of processes concerned in the formation of science: (1) Decomposition of facts; (2) Measurement of phenomena; (3) Explication of conceptions; (4) Induction of laws of phenomena; (5) Induction of causes; (6) Application of inductive discoveries." (P. 143.) It was his objective manner of facing facts, his want of interest in the psychological processes which determine the arriving at a conclusion, that hid from Whewell the art of discovery. Unhappily his influence over Mill was paramount. Yet Mill recognised that "observation and experiment are the ultimate basis of all knowledge". (Bk. 3, ch. 10, § 8.)

stood that men acquainted closely with science, like Whewell and Jevons, who were not psychologists, should be unaware of the methods which they resort to in scientific enquiries, and that spectators, like John Stuart Mill, who discern only the final product, and that through the glasses of classicism, should not be explicit concerning the complex process which precedes the final drawing of a conclusion.

SECTION VII.—CONCLUSION.

§ 18. In the preceding Sections it was explained wherein the problem of methodology lies. Individual minds left to their own devices, we learnt, are lost in clouds of words, and are prone to evolve error rather than truth. Thinking, however, in concert, men correct one another, and gradually, through the ages, develop methodological traditions of an increasingly higher order. Yet since these traditions lack unity, because each of them has developed in materially different circumstances, they cannot be readily applied to new problems, nor can they be convincingly and systematically communicated.

Concurrently, and keeping pace with the growth of these traditions, more or less crude systems of methodology, we observed, develop, and then pass away into more or less improved systems. The first impulse, encouraged by the belief, due to limited experience and naïve desires, that the world of fact is devoid of complexity, was tacitly to postulate that final truth is the goal of the man of science, and accordingly the logic, associated for us with the name of Aristotle, held sway for a score of centuries. Indeed even now works on logic frequently regard the subjective intelligence and the objective world as if their processes could be neatly analysed and separated, at least by superior minds. So strong has been the primitive absolutist influence that methodological thinkers of later times, such as Descartes and Mill, oblivious of the changes wrought by time in the scientific conception of the world, strove to extend the old logical methods without attempting to shake the principle of absolutism or finalism in knowledge and thought. Only one eminent methodologist, Francis Bacon, explicitly recognised that the complexity of facts required methods which should accommodate themselves to the various imperfect phases of a scientific enquiry, and that such methods were not given, but had to be laboriously found. Lacking such a relativist foundation in harmony with the data and the needs of modern science, logic fell into disrepute, and the problem of this treatise is therefore, on the basis of the recognition of the socio-historic and consequently relativist nature of thought, to elaborate a scientific methodology, and thus to re-instate logic into its exalted position as the mistress of the sciences.

PART II.

DEFINITION OF SOME IMPORTANT METHODOLOGICAL TERMS.

SECTION VIII.—OBJECT, FACT, ENVIRONMENT.

§ 19. (A) *OBJECT*.—The term Object is, as such, perhaps undefinable. *A given object is that (object) which we choose to regard as having a separate or separable existence.*¹ An atom in a molecule, a molecule in a nucleus, the nucleus itself, the cell, a piece of tissue, an organ, a system of organs, the organism, and so on, may severally be regarded as entities. (Conclusions 25*i* and 22.) A tree, a wood, a landscape, a mountain range, a country, a continent, the earth, the solar system, the sidereal system, and the Universe, are objects.² In a puzzle picture, whose primary object it is to deceive, and in many geometrical designs, the same set of lines, according to the manner in which they are viewed or interpreted, yield dissimilar objects. Similarly with sounds. Uttering, for instance, several times in rapid succession the word “plea”, we may imagine, according to choice or circumstance, that we are saying “leap” or “plea”. Again, we may disregard the changes which are produced in the passage of time—from the zygote to the new-born babe, and from the new-born babe to the man bowed down by age, or the transformations due to position in space and to other circumstances. Furthermore, just as we may ignore changes of time and space, we may pass over determinate quantity, as in the concepts man, redness, solidity, and the like, where the terms imply highly abstract and generalised facts. Similarly, inasmuch as animate beings derive their nature from other animate beings, as a son from his parents; an animal and a plant from other animals and plants; one species from a preceding one; therefore mankind and the whole of animate existence may be conceived as one and undivided. The current methods of classification are, however, based on practical considerations, and separate movable objects—an animal, a table—are the conventional types of objects as such. Beyond this necessarily limited view of apprehending nature, convenience, interest, and an easy grasp and separation

¹ “Gegenstände oder Dinge sind von unserm Willen unabhängige Komplexe von Empfindungen, denen räumliche Selbständigkeit und zeitliche Stetigkeit zukommt.” (Wundt, *Logik*, vol. 1, p. 454.) It need scarcely be pointed out that a complex of sensations is a thing or object, and that no sensation complex is entirely independent of discriminating intelligence.

² “We can call a pile of wood, a pyramid of balls, or a heap of sand a unity or a thing, although it contains a plurality.” (Sigwart, *Logic*, vol. 2, p. 82.) Sigwart discusses this subject somewhat fully, and Locke has a few apposite paragraphs in his *Essay on the Human Understanding*, bk. 2, ch. 23, § 1-2.

by the senses or the intelligence, commonly determine classification.

Sundry aspects in the conception of objects, derived from a methodical analysis based on Conclusion 25*i*, and in agreement with Conclusion 20, should be noted: (1) the several atoms or smallest particles in an apple, for instance, are judged to be objects. (2) An apple, consisting as it does of various parts (peel, pips, etc.), is regarded as one object. (3) We separate sense impressions derived from many apples and name these qualities, as solidity and sweetness. (4) We disregard those special states of the apple which are ascribable to particular causes, *e.g.*, disease. (5) The apple, conceived as changing from an arbitrary point (the fertilised ovum) to another arbitrary point (the state of decay), is considered as possessing an independent existence. (6) As with the development of the apple, so with its antecedent and subsequent states—the time before fertilisation of the ovum and after decay, practical reasons induce men to pass them over. (7) We form classes of objects in time sequence, of higher and higher categories, as in the theory of evolution where the rich life of to-day, including our apple, is traced back to the detachment of our planet and prior. (8) We combine smaller into larger aggregates in order of space—apple, apple tree, orchard, village, district, province, country, continent, earth, solar system, Western Universe, Island Universe, Universe. (9) Influences of temperature and moisture, of atmospheric pressure, of gravitation, the constant removal and addition of minute particles, and the environmental influences generally as summed up in external physical, biological, and cultural influences are, for practical purposes, arbitrarily ignored in the concept of an apple. (10) In all observation of an apple or of any other object memory enters in at least two forms—as (a) special memory, in that we cannot focus an ordinary object in one single act or moment of time, and as (b) general memory, in that we only recognise an object by connecting it with preceding experiences.¹

Human convenience, then, determines the definition of an object, and, omitting the Universe as object, *we might define an object as a more or less arbitrarily selected or framed portion of the differences-containing Universe² which, for the sake of convenience, we choose to regard as having a more or less*

¹ We pass methodically, according to Conclusion 27, from extreme minimum to extreme maximum. (1), (2), (3), and (4) are the four different aspects of an average apple or object other than single "atom". (5) and (6) follow development within, before, and after the apple's life time. (7) and (8) furnish the relations in time and space. (9) enumerates environmental factors. And (10) allows for the psychological aspect.

² The less differentiated we imagine the constitution of the Universe to be, the greater will be our difficulty to perceive "objects". For instance, a white sheet of paper, viewed from a little distance by even illumination, can only be broken up with difficulty into subsidiary objects.

separate and durable existence. Plato's permanent types do not appear therefore to receive any warrant from an analysis of the term Object, and Kant's Thing-in-itself apparently dissolves in the examination.

Science is concerned with objects, and consequently it is important that we should be methodologically aware of the artificiality, ambiguity, or arbitrariness of the term Object. In applying, therefore, methodological canons, we should assume that the phenomenon we are scrutinising has only a separate or definite existence in a very limited sense, and that we should hence beware of isolating it too rigidly in our thought.¹ (The general nature of a given object is defined in Conclusion 3, and some of the main practical difficulties encountered in defining an object will be discussed in Conclusion 17.)

§ 20. (B) *FACT*.—Consonant with the preceding analysis of the term Object, *a fact may be defined as a valid theory*² *in regard to the exact nature and relations of a certain portion of reality.* That the sun gives light, that fire burns, that we are breathing, may appear to be occurrences so certain that the expression "valid theory" hardly does justice to them. Error, however, not only tends to invade the most unexpected places, as men of science will be the first to admit, but dreams and mental disorders further warn us against indulging in absolutist statements. Giddings says in his *Inductive Sociology* (p. 13): "A fact, in the scientific sense of the word, is the close agreement of many observations or measurements of the same phenomena."

§ 21. (C) *ENVIRONMENT*.—We may state that *that which surrounds any fact constitutes its environment.* Thus the individual's environment is the Universe *minus* himself, whilst he forms the environment for the world external to him. In the realm of ideas the same definition applies. When it is said, therefore, that man is a creature of his environment, it should be borne in mind that, being an integral part of the Universe, he shares power and influence with his environment. Similarly, when his impotence is sought to be demonstrated by fatalists on the assumption that he is a product of antecedent causes, we are bound to observe that as a component of the Universe he also is a cause. The law of action and reaction applies here.

¹ In his highly suggestive volume *l'Evolution créatrice*, M. Henri Bergson provides good grounds for believing that it is only the practical nature of our intelligence, aiming as it does commonly at results and not at knowledge, which renders us sometimes forgetful of the fact that reality is in great measure a flux, and that definite objects, spaces, and times are unreal or, let us say, artifacts. Conclusion 27 emphasises, by its method of degree-determination, the need of doing justice to this flux. Complete indefiniteness, however, would be indistinguishable from blank nescience.

² "In its most proper acceptation, theory means the completed result of philosophical induction from experience." (Mill, *Logic*.)

For practical ends the environment is frequently interpreted in a narrower and more specific sense, as in Conclusion 17c. It is, in fact, of signal importance not only to employ the term with caution, but to remember in every enquiry both the vital fact involved therein, and the need of making thereof a limited use.

SECTION IX.—OBSERVATION.

§ 22. To marvel at the twinkling stars; to contemplate the periodic transformations in the form of the moon and both its path and that of the sun; to observe the ebbing and the rising of the tide; to note stones falling and smoke rising; to perceive the flash of lightning and hear the rolling thunder; to experience sunshine, wind, rain, snow, and hail; to notice the conspicuous seasonal changes in plant life, and the general facts of variety, growth, and decay in animate beings; to learn of men of different shades of colour, and of the fortunes and falls of empires and nations; to visit churches, art galleries, factories, and homes, and to take stock of other striking and patent facts in the way the man in the street does, has scientifically a minimum value, because in no such instance are the material factors revealed to the unaided sense and the unassisted reason. Apart from science, he who is uninstructed is unaware, for example, that plants abstract from the air carbonic acid, and return to it oxygen and water vapour; nor that the action of the sun on the chlorophyll, or the green colouring matter, of plants leads to the initial production of living matter from non-living matter; nor that bacteria help plants in obtaining nitrogen from the soil; nor that the action of earthworms prepares the soil for vegetation; nor that the form, the bright colours, the scent, and the sugary secretions of flowers have developed for the purpose of attracting insects which act as fertilising agents; nor that plants evolve, and are constituted of minute cells; nor indeed anything of consequence regarding the vegetable kingdom; nor that enzymes, internal secretions, and vitamins exist, and are indispensable to the maintenance of life, or that the cells possibly utilise molecular energy, and are affected by molecular movements; nor that "physiology consists largely in tracing the way in which Oxygen enters the body, the manner in which it is distributed to the tissues, and the various phases of vital activity which it brings about within the living tissues" (W. A. Locy, *Biology and its Makers*, p. 183); nor that food is directly transformed into energy without being first converted into heat. And what is true of his ignorance of life is true quite generally. Astronomical, geological, electrical, chemical, meteorological, and other leading natural laws, are wholly beyond his conventional range, and the genesis and meaning of cultural phenomena are wrapt for him in an impenetrable fog. So far as observing what is

significant is concerned, he is almost exactly in the position of a blind man in respect of colours.

This is not astonishing when we ascertain how little is disclosed by ordinary experience. How is the uneducated man to read the story of the stars, the earth, or the stratified rocks? How is he to determine the depth of the strata or of the sea, or the diameter of the earth or moon? How is he to follow the system of mountain ranges; divine that volcanic regions are situated close to the sea or to large lakes; or suspect the existence or understand the cause of the trade winds? How is he to surmise that the lump of flesh he is inspecting is a muscle, and that buried in the lump are tendons, nerves, arteries, veins, all held together by connective tissue; or how is he to determine the composition of the blood and its functions; or how is he to follow the processes of digestion and absorption of foodstuffs or the segmentation of the ovum? How is he to decipher the history of mankind which stretches to the tertiary period, and the complex signs of his own age?

The information of what is remote in time and space is to be acquired only by collective enquiries frequently lasting for generations. Such facts defy conjecture, and much less is the world of molecular masses open to his gaze, seeing that this world is wholly screened from unaided sight and touch. The weight of radium which may be detected experimentally by means of the electrometer is 0,000,000,000,001 of a gram; the quantity of xenon in the atmosphere is one part in 170,000,000; there are said to be about 640 trillions of hydrogen molecules in one milligram of the gas; the diameter of a molecule is perhaps about 2×10^{-8} cms.; the number of molecules in 1 ccm. of air under normal conditions is about 27×10^{19} ; a molecule collides about 6,000,000,000 times a second; and the mass of the electron is about $\frac{1}{1800}$ th part of that of the hydrogen atom, the weight of the latter being 1.63×10^{-24} gms. When it is considered that scientific knowledge—as in biology, chemistry, light, heat, electricity, and magnetism—is vitally contingent on an acquaintance, however indirect, with substances invisible to the naked eye or imperceptible altogether except indirectly, as with certain classes of bacteria, the impotence of common observation becomes manifest. Hence we find that most scientific inquirers seek by increased refinement of methods to pierce into the world of the infinitesimal. Consequently, so far from desultory observation suggesting to the man of science an extensive and true hypothesis, he and hundreds of his confrères almost exhaust themselves in establishing a few comparatively narrow generalisations grounded on an astounding number of observations—witness, for example, the almost infinitely laborious process of discovery of the numerous glandular secretions which, at different stages, prepare the ingested food for ab-

sorption into the human system. Scientific observation therefore commonly presupposes a rapidly growing arsenal of ingenious and delicate instruments or other adjuncts, often devised or perfected by the men of science themselves.

An illustration drawn from Herschel and Jevons exemplifies the importance of circumspect observation. Shells had been encountered on high mountains, and seven hypotheses had been propounded to account for the shells. Some men contended that the shells had been left behind by the retreating waters of the "deluge"; Voltaire argued that pilgrims had dropped them there; others thought they were freaks of nature, or that they were due to fermentation, to the influence of the celestial bodies, or to birds feeding on shell-fish; and a seventh group of persons claimed that they were the remains of living forms covered by accumulations of *débris* of various kinds, and subsequently exposed or detached. Now the first six hypotheses were practically gratuitous surmises, since they were evidently not derived from anything like wide observation. And if the seventh one was merely a fortunate hit, not grounded on, nor to be succeeded by, exhaustive observation, it was to all intents and purposes as unprofitable as the other six. Only the prolonged, extensive, minute, and accurate observations of such men as Sir Charles Lyell and Archibald Geikie, have enabled geologists to propose valid generalisations, and to proceed deductively with some effect. "Comparison must be made with facts purposely selected so as to include every variety of case, not omitting extreme ones, and in sufficient number to afford every reasonable probability of detecting error", and all conclusions need to be "in exact accordance with numerous observations purposely made under such a variety of circumstances as fairly to embrace the whole range of the phenomena which the theory is intended to account for". (Herschel, *Discourse*, [219-220].)

In earlier stages of a science—when comparatively much material has been accumulated, but yet far too little to permit the detailed testing of a sweeping conjecture—the formation of a large hypothesis is only admissible when its purely provisional character is stressed. Within these limits it has marked advantages. If, however, the apparent and partial consistency of the hypothesis with the imperfectly known facts is regarded as of itself conclusive evidence for its correctness, we are likely to be imposed on by a mirage, and the progress of science is arrested. A pertinent illustration of the above is offered by the story of the highly ingenious and purely hypothetical phlogiston theory, which we accordingly quote:—

"The theory of phlogiston was originally broached as a theory of combustion. According to this theory, bodies such as coal, charcoal, wood, oil, fat, etc., burn because they contain a combustible principle, which was assumed to be a material substance and uniform in character. This

substance was known as phlogiston. All combustible bodies were to be regarded, therefore, as compounds, one of their constituents being phlogiston: their different natures depended partly upon the proportion of phlogiston they contain, and partly upon the nature and amount of their other constituents. A body, when burning, was parting with its phlogiston; and all the phenomena of combustion—the flame, heat and light—were caused by the violence of the expulsion of that substance. Certain metals—as, for example, zinc—could be caused to burn, and thereby to yield earthy substances, sometimes white in colour, at other times variously coloured. These earthy substances were called *calces*, from their general resemblance to lime. Other metals, like lead and mercury, did not appear to burn; but on heating them they gradually lost their metallic appearance, and became converted into *calces*. This operation was known as calcination. In the act of burning or of calcination phlogiston was expelled. Hence metals were essentially compound: they consisted of phlogiston and a calx, the nature of which determined the character of the metal. By adding phlogiston to a calx the metal was regenerated. Thus, on heating the calx of zinc or of lead with coal, or charcoal, or wood, metallic zinc or lead was again formed. When a candle burns, its phlogiston is transferred to the air; if burned in a limited supply of air, combustion ceases, because the air becomes saturated with phlogiston.” (E. Thorpe, *History of Chemistry*, vol. 1, pp. 71–72.)

Lavoisier’s theory that in combustion substances combine with the oxygen of the air—the very reverse of the assumption of the phlogiston hypothesis that substances lose in combustion—was the product of a more advanced age.

The very ground we tread on has an immeasurably richer meaning for the man of science than for the uncultivated:—

“Turn up a sod of earth in a pasture in winter, and at first sight it seems to consist of two well-marked portions, a living and a dead one—the green grass above and the black soil beneath it. But look closer into the mass, and what then do you see? A whole network of living beings. Matted roots of grass, just as much alive as the green blades above, spread and interlace themselves through the seemingly dead portion. Bulbs of bulbous buttercup, of orchids, of garlic, lie hidden in it everywhere. Root-stocks of plantain, of chervil, of pimpinel, of daisy, are knotted among its clods. Gaze closer still, and you will see that it is all full of tubers or stocks of lesser weeds, in their dormant condition, all ready to spring afresh at the first breath of April. How the endless bulbs and corns and tap-roots manage to stow themselves away in so small a space is to me a perpetual mystery; in winter you hardly notice the little potato-like pills of the lesser celandine, but in spring the plants cover the ground with their golden blossoms, to be succeeded in due course by the spotted orchid, the buttercups, the centauries, the hawk-weeds, and all the countless flowers of July and August. They are packed as tight as sardines in a tin. As for the seeds of small annuals they lurk there by the thousand; sift out a little of the soil, and plant it in a pot, and, *hi presto!* to your surprise, weeds will spring from it in incredible numbers. The whole mass teems with dormant germs innumerable.

“It is the same with animals. You think of this soil as dead; but it is undermined by rabbits, rats, moles, and lizards. It swarms with invertebrates. Larvæ of tiger beetles lie in wait in its crannies; grubs and worms without end find a living in its hollows. Woodlice and petty snails lurk under every stone; centipedes and wire worms crawl through its interstices; testacella pursues earthworms as the ferret pursues the rat; a whole underground fauna lives and moves and has its being in that seemingly dead congeries. Turn up a handful of earth, and examine it with a pocket lens; you will find it alive, like an ant-hill, with endless

tiny mites and crawling creatures. Even if we take into consideration only the plants and animals visible to the naked eye, this soil beneath our feet is one heaving, seething, moving mass of living organisms; it has its jungle-law and its penalties, its feuds and its alliances, its fierce struggle for life and its unspeakable tragedies.

"But when we pass from the visible to the invisible world, the variety and fertility are even more conspicuous." (Grant Allen, *The Hand of God and other Posthumous Essays*, 1909, pp. 96-97.)

A second illustration by Jevons indicates how observation and generalisation melt into each other. Examining the problem of the rainbow, he concludes that "a beam of light and particles of water, in a particular position, are the necessary antecedents or causes of the bow of colours"; and he adds that "this is nearly all that simple observation can tell us, and it forms merely the first step of preliminary observation". (*Primer of Logic*, p. 96.) Yet to many persons this statement will appear to be a broad generalisation, since it comprises not only all coloured bows due to rain, but all coloured bows whether due to rain or to other states of water. The fact is that by observation we scarcely ever mean the examination of an individual object at one particular moment from one particular angle, but a process involving the examination of individual objects under different conditions and the conscious comprehension of all material resemblances to other similar objects, accompanied by the studied neglect of all immaterial divergences. Not infrequently, however, men of science proceed even further, and include the examination of a series of classes, as Jevons' illustration indicates.

Telepathic theories offer an example of how seldom the complexity of the process of observation is recognised. Desirous of verifying a passage in a volume which I am reading, I betake myself to the sitting room of the lady at whose residence I am temporarily staying in order to borrow a Bible. As I leave my apartment, I meet the lady with a Bible in her hand. Did she divine my thought? Perhaps I determine to note kindred instances, and, after collecting a certain number, I possibly reach the conclusion, as so many individuals have done before me, that telepathy represents a proved mode of human communication. Yet, scientifically, the problem is not simple at all, for we must search for instances which resemble this one, *except* for the peculiarity of the arresting coincidence. That is, I must ask myself: Do I often require a book, another person, a thought, without the book, other person, or thought being encountered unexpectedly? The self-evident answer to this query at once casts doubt on the first interpretation, for the number of possible to real and impressive coincidences is almost as infinity to one. In fact, if we are thorough, as it is our duty to be, we shall institute a systematic enquiry into the nature and frequency of coincidences, and it is much to be hoped that this will be undertaken by some learned body.

Or, to consider another related problem, that of telepathic hallucinations. Some years ago the (London) Society for Psychical Research selected out of a very much larger aggregate twenty cases of hallucinations alleged to have been experienced by some one at the time of the death of some person known but not expected to die. The investigators argued abstractly that the law of probability made it extremely unlikely that these very remarkable coincidences should have been "chance" coincidences. Now, on closer scrutiny, we learn that these hallucinations were experienced mostly about the time of waking, going to sleep, or dozing, including night time and post-prandial siestas.¹ It would have been, therefore, desirable to engage in an objective or even experimental study of these conditions in order to throw further light on the problem. If this had been done—the present author has attempted it—it would have transpired that in such a peculiar state hallucinations are not rare, and that in this condition men believe themselves to be awake when they are partially asleep. This has a double bearing on the problem, for, first, it teaches us that hallucinations are not infrequent, and that they have as a rule what is admittedly a natural cause, to the extent of being indeed almost wholly at the mercy of a competent experimenter (see *Mind of Man*, pp. 433–436), and, secondly, that expectancy favours hallucinations. Moreover, we appreciate the gravity of the fact that in not *one* instance were those who were said to have experienced the hallucinations able to produce a recording note written at the time. (The editors facetiously speak of "mental" notes.) If to this be added that in not a few of the cases there was anything but a "chance" coincidence, as the theory assumes; that these hallucinations did not present themselves altogether or mainly to near or dear relatives and friends; and that no hallucinations occur in myriads of daily happenings of an analogous nature, we shall be compelled to call in question the strictly scientific nature of the enquiry.

We are supported in our criticism of telepathy by other data, which indicate that random surmises are of scanty use in enquiries of this kind. To venture on one or two illustrations. At a committee meeting I perceive my neighbour gazing half-abstractedly at my notes. Presently he informs the chairman that he desires to propose a certain motion—a motion which he had read off my notes without really being aware of this! Or a friend tells me that by "willing" he had compelled somebody at the table, at which several of us are seated, to write his name backwards, when the fact is that the "willing" was suggested by what he saw somebody do, and not *vice versa*. Or I observe that I ask myself regularly the question "Is the blotting paper there?" when that article is perceived by me

¹ Volume X of the Proceedings of the Society for Psychical Research.

to be in its place, but as regularly omit it, when it is not there—the usual explanation being that the sight of the article gives rise to the enquiry, and not the reverse. Or to consider an even more telling and yet common occurrence: bent on recalling an event when somebody with me is engaged on the same quest, I think that we have simultaneously succeeded when in reality I am confusing hurried repetition of what my neighbour says with independent recollection.¹ Brushing aside, then, fraud of every kind as well as gross self-deception, both of which are far from being rarities, we still infer that it argues monstrously lax observation to collect at random a series of affirmative instances of a selected order and ground thereon a far-reaching conclusion. Yet who would say that the examples analysed here are not almost typical of most of the so-called scientific work beyond the frontiers of the established sciences?

A kindred and related instance to telepathy is that of the widely-obtaining attitude towards the problem of sub-consciousness. Poincaré had noticed that solutions of important mathematical problems occurred to him not infrequently when he was apparently absorbed in considering some matter extraneous to these problems; whence he concluded that the sub-conscious activities of the mind possess greater value than its conscious activities. Methodologically this seems a precipitate conclusion to draw. Before we are entitled to deliver such a verdict, we must be clear—following Conclusions 27 and 28—concerning what “conscious” and “sub-conscious” mean; where the two possibly pass into one another; whether “spontaneous” solutions of an inferior character do not present themselves to us; whether there are not multitudes of cases in which “sub-conscious” thought is superficial like, or even more superficial than, conscious thought; and we must be furthermore thoroughly satisfied about the precise facts relating to the alleged spontaneous solutions—whether, for instance, we are at the particular moment really absorbed in something else, or whether it is not a question of a pause favourable for recollection or cogitation.

Prof. William James has sought the nature of religion in the realm of the sub-conscious; Hartmann has written a ponderous work on the *Philosophy of the Unconscious*; at the present moment Freud's psycho-analysis is developing into the psychology of the sub-conscious; and it would require pages to enumerate the various virtues and activities attributed to the sub-conscious in man. Nevertheless one vainly looks for a scientific analysis or cautious discrimination pertaining to fundamentals in the various dissertations on the subject. Without pronouncing on the basic issue as to whether “sub-consciousness”, or unconscious consciousness, is a fact, we may say that the

¹ An identical explanation frequently applies when two individuals are said to yawn simultaneously.

enquiry has been conducted in an unsatisfactory manner, and that whilst normal psychology is yet a primal forest waiting for pioneers to explore it, it is unlikely that any headway can be made at present in matters connected with abnormal psychology. Observation, it is disconcerting to learn, is yet an art almost entirely neglected outside the physical and biological laboratory. So far as the sciences relating to man are concerned, it is very much as if we lived in pre-Baconian days when the need for scrupulously circumspect and varied observation was unsuspected and audacious theorising or abject reliance on authorities constituted usually the *alpha* and *omega* of the method employed in discovery.

Consider, again, M. Henri Bergson's defence of indeterminism. According to him "we are free when our acts emanate from our entire personality" (*Les données immédiates de la conscience*, ed. 1906, p. 131); but in so far as we are prompted by external or fragmentary incentives, our conduct, in M. Bergson's opinion, is determined. In a methodological age we should know what to expect of an essay where such a view is advanced. The author would propound his hypothesis, and then proceed to its substantiation. He would be meticulously careful to prove that we sometimes act with our whole nature; that in such instances we are not actuated by external influences either directly or indirectly; and that a higher or different value is, for certain produced reasons, to be ascribed to decisions of a purely internal nature. Unfortunately methodological procedure has not yet become second nature in man, and so M. Bergson experiences no subjective qualms or objective difficulties in concluding his exceedingly interesting psychological study without any serious effort to convince us that we ever act with our whole nature, or that, if we did so, our whole nature is not an external or partially external product. Where the man of science would feel that nothing short of a highly developed science of mind could authorise him to entertain such a hypothesis, the philosopher blandly assumes his facts and is sublimely unconscious that he is merely indulging his roaming fancy.

M. Bergson is but typical of this attitude of the philosopher towards reality. For instance, Mr. Herbert Spencer, before him, had sought to reconcile religion with science. Without even a casual attempt to elucidate the meaning of religion, he ingenuously postulated that "Religion under all its forms is distinguished from everything else in this, that its subject matter is that which passes the sphere of experience". (*First Principles*, 1875, p. 17.) By such a procedure everything, of course, can be demonstrated, and that is precisely what philosophers unconsciously do, and men of science consciously and severely leave undone. Only a universal conviction that truth can be solely established by scientifically inspired socio-historic

research, will check the incessant, but fruitless, endeavours of individuals to enlighten mankind on the most fundamental issues of existence by advancing theories which are ambitious and elaborate, but, at most points, out of touch with reality.

§ 23. Without a close and full examination of facts we are liable to be gravely misled, as is impressively illustrated by the Shakespeare-Bacon controversy. The general argument of those who contend that Bacon was the author of the plays commonly attributed to Shakespeare, runs somewhat as follows. These plays are of such supreme excellence that he who was responsible for writing them should be regarded as one of the greatest master minds the world has known. Now William Shakespeare was the son of humble parents, enjoyed only an elementary education, was a mediocre actor, was primarily interested in acquiring wealth, had no consciousness of his greatness, and was so uninteresting to his contemporaries that few traces of his life are discoverable even by the most diligent research. This commonplace actor, this conventional figure, could never have been the creator of the superb comedies and tragedies ascribed to him. On the other hand, his contemporary, Francis Bacon, was the dominant spirit of his age, and to him undoubtedly should be assigned the merit and the glory of having ushered onto the world's stage the plays reputedly Shakespeare's. If it be objected that the plays are ostensibly by Shakespeare, the reply proffered is that, owing to Bacon's high social position and the low status of Elizabethan playwrights, the authorship could not be revealed.

Abstractly, at least on the negative side, the case for the Baconian origin of the plays in question appears almost irresistible. Now to the facts. Shakespeare's father, John Shakespeare, occupied successively all the higher civic posts in the fairly large town of Stratford-on-Avon, where he lived; and his wife belonged to a respectable country family. The sons of numerous fathers of the merchant class similarly situated, have risen to the most prominent ranks. However, financial misfortune overtook John Shakespeare, and therefore his illustrious son's education was probably limited by what the grammar school of the town offered. There, we may assume, he assimilated what such an educational establishment provided, which need by no means have been negligible in quantity or quality. Besides, fortunately, culture is not a mere matter of school drill. For aught we know to the contrary—*pace* Ben Jonson—he might have become a great scholar through private study. Arbitrarily to limit his possible intellectual attainments, would be unfair. Of course, Shakespeare's plays might have exhibited such a grasp of the sciences, the arts, and other subjects taught at the universities, that it would be difficult to account for John Shakespeare's son acquiring them; but since philosophers, men of science, politicians, and artists, do not ponder over his

plays to increase their technical knowledge and insight, we may ignore this aspect.

However, is it consistent with the nature of things that a mere actor should be the author of incomparably great plays? Well, a high percentage of the dramatists of his day were temporarily or permanently actors. Not only, therefore, does Shakespeare's authorship not militate against his having been a dramatist, but it is almost what we should expect. As a matter of fact, his intimacy with the stage, and his regular income derived therefrom, were probably powerful aids to his producing good plays.

And how is his obscurity to be explained? We answer, by the general fact that there is not one Elizabethan playwright, except Ben Jonson, who was a critic as well, of whom we possess any but the most meager record. Even Beaumont and Fletcher, who belonged to families noted in their day, are without a private history for us. Nor is this difficult to understand. In those days there were no daily papers or other periodicals, nor did that age command other means of counteracting this deficiency. Hence playwrights, who were tabooed socially, lived and died, without fame noising abroad their private ventures and adventures. In reality, their very plays were ordinarily not their property, and in rare cases only did they publish or supervise the publication of their works. It was even common for plays to be published without author's name, as if the author was of no consequence.

We should, further, remember that Shakespeare was not regarded by his own age as in any way unique or strikingly different from other playwrights. From the documents which have escaped the ravages of time, we are bound to conclude that he was considered as one dramatist among a number, though one of the first caliber. Shakespeare had therefore no valid reason why he should conceive himself as differing markedly from his fellow playwrights, or why he should not seek to retrieve his family's financial losses.

Yet how could such a plain bourgeois write exquisitely, as Shakespeare did? This, too, should be answered in the light of his time. His manner of writing was that of a school of playwrights, and the utmost that one could say is that whilst he was on the whole the first of the school, he exhibited no stateable peculiarities, except those of frequent superiority. That is, practically all that has been said about Shakespeare, is literally true of his fellow playwrights. Circumstances have concealed this, but an impartial study of the school of Elizabethan playwrights renders this manifest. His genius is therefore first and foremost an expression of his age, and is a social, and not an individual, product.

If the above be conceded, it might still be argued that it is incumbent on us to connect the actor with the author, and

both with the William Shakespeare of Stratford-on-Avon. This, too, is not difficult to compass. Diverse documents render it evident that an actor of that name existed at the time at the very theatre where the Shakespearean plays were regularly performed. Moreover, one of the Prefaces to the 1623 Folio, which many Baconians claim to have been edited by Bacon himself, contains definite statements by his fellow actors Heminge and Condell, to the effect that the author of the plays and the actor were one. They say that their object in publishing the collected edition was "to keep the memory of so worthy a friend and fellow alive as was our Shakespeare"; and Ben Jonson, in a famous passage in his *Timber*, published in 1641, takes this for granted (pp. 97, 98). In that Folio, too, there are allusions directly connecting Shakespeare with Stratford-on-Avon, even his monument being referred to. Thus Ben Jonson, in his Ode, addresses Shakespeare as the "Sweet Swan of Avon", and Leonard Digges, in his poetical effusion, speaks of "... thy Stratford monument".

Lastly, in Shakespeare's will there is mention of three of his fellow actors, John Heminge, Richard Burbage, and Henry Condell, whilst a fellow actor, A. Phillips, in his will, left "to my fellowe, William Shakespeare, a thirty-shillings piece of gold". (On Shakespeare, the actor, see Sir Sidney Lee's *Life of Shakespeare*.) The chain of evidence in favour of the theory that the reputed author of the plays is the real author, is, therefore, as complete as we could wish, short of extensive biographical documentation.

Now to Bacon and the plays. Is it not incredible that Bacon should have published the plays under another's name, a man well-known in the community, said by Baconians generally to have been utterly incapable of composing them? To continue successfully such a deception for twenty years or more, as is implied, would be nothing less than miraculous. We do not encounter here a fictitious pseudonym; but an individual dwelling in what was then the dramatic hub of the Elizabethan universe, and perforce known to multitudes. Only a Shakespeare, it is evident, could properly impersonate a Shakespeare.

Here is another small, but significant point. The title page of the first Folio has a portrait described as that of Shakespeare's. Now how extraordinary this is on the Baconian theory! Why have had a portrait at all? And if there was to be one, why not subtle suggestions of the person of Bacon? The portrait is in flagrant contradiction with the assumption that the plays were not by Shakespeare.

How strange, too, that not only should the sponsors of the first Folio be two actors who speak of the author as a fellow and friend of theirs, but state repeatedly that the author is no longer among the living. They protest: "It had been a thing, we confess, worthy to have been wished, that the author

himself had lived to have set forth and overseen his own writings; but since it hath been ordained otherwise, and he by death departed from that right, we pray you do not envy his friends the office of their care and pains, to have collected and published them."

Again, according to Ben Jonson's Commemorative Ode in the first Folio, amply and conclusively confirmed by Richard Farmer in the succeeding century, Shakespeare had "small Latine, and less Greeke". Indeed, few, if any, of his fellow playwrights seemed so dependent on translations from the classics or quoted so little Latin. Yet Bacon was a brilliant Latin scholar, and his acknowledged works abound in references to untranslated passages, and quote not a few in the original. Moreover, the later seventeenth and the eighteenth century were in emphatic accord with Ben Jonson, that Shakespeare lacked "art", which would constitute a ludicrous statement if applied to Bacon. That is, the judgment of his own and that of the succeeding century conforms precisely to what we should expect of William Shakespeare, the son of John Shakespeare, of Stratford-on-Avon, and is in violent conflict with the theory that the super-learned Bacon was the author of the plays in dispute: Shakespeare's helpless dependence on translations completely disposes, of itself, of the Bacon theory.

Much might have also been said of the different styles of the two writers; of Bacon's absorbing and life-long interest in scientific method, of which there is no sign in Shakespeare's plays; of the absence of the romantic element in Bacon's writings; of his wanting time to write over thirty plays when his hours were already so full.

When the principal facts, only obtainable through close historic studies, are thus focused, we learn that there is every reason for believing that Shakespeare wrote the plays attributed to him, and that Bacon did not. Yet bare surmises and diletante enquiries would have only led us into ever deeper quagmires. Facts cannot be divined.

Even more impressive from the viewpoint of scientific method, is the solution of the problem of Shakespeare's real status as a dramatist. According to the conception generally prevalent at the present day, Shakespeare is the prince of the dramatists of the modern era. Compared to him, every other dramatist is a Lilliputian at the side of a giant, or rather Shakespeare is altogether unique and incomparable. His fellow dramatists of the Elizabethan and Jacobean ages are of a different, almost infinitely lower, stamp; his contributions to dramatic literature are quite individual; his genius cannot be explained by anything but his innate greatness; and, accordingly, in articles and works on Shakespeare, his dramatic environment is almost uniformly ignored. His predecessors are sometimes referred to, but mostly in far from flattering terms. In fact, the theory that Francis

Bacon wrote Shakespeare's plays is directly attributable to the exceptionally high estimate placed on Shakespeare's plays. Such being the general opinion three centuries after Shakespeare's death, to question it is regarded as verging on boorish ignorance or lamentable eccentricity.

Our problem, then, is to inquire into the soundness of the present-day attitude towards Shakespeare.

As we might anticipate from the drift of our special studies generally, Shakespeare was no freak of nature nor an eccentric. Shortly before he began to write, a number of remarkable dramas appeared on the stage. And so far as the lighter side was concerned, it was well represented by John Lyly, who was in diverse ways one of Shakespeare's prototypes, and by Robert Greene's *James the Fourth*, which is a sort of model for Shakespeare's comedies. Shakespeare's common people, his brilliant repartee, certain of his famous comic figures, and his typical women, are foreshadowed in Lyly, as well as his superior poetical and reflective vein. Again, Marlowe was one of Shakespeare's exemplars on the side of tragedy, of historical plays, and of the *grand style*. His indebtedness to his predecessors has been not infrequently acknowledged, as, for instance, by Sir Sidney Lee, in his *Life of Shakespeare*, who writes: "Kyd and Greene left more or less definite impressions on all Shakespeare's early efforts. But Lyly in comedy and Marlowe in tragedy may be reckoned the masters to whom he stood in the relation of disciple on the threshold of his career. With Marlowe there is evidence that he was for a brief season a working partner." (*Op. cit.*, p. 95.)

Indeed, the authorship, in part or wholly, of several of Shakespeare's early plays, has been frequently called into question. The generality of scholars favours the view that *Titus Andronicus* has been mistakenly ascribed to Shakespeare; that the three parts of *Henry VI.* were slightly adapted, rather than written, by Shakespeare; and that sundry other early plays of his were more or less adaptations or imitations. These discussions affect us fundamentally, for if scholars are divided in opinion in respect of authorship of plays or part plays, the self-evident implication is that there was only a measurable difference and distinction between Shakespeare's dramatic efforts and those of his contemporaries. If he were really unique, there could be no disagreement among experts.

In 1598 appeared Francis Meres' *Palladis Tamia*, wherein the list of Shakespeare's plays to date is given, and where his work is repeatedly and highly lauded. According to this volume, Shakespeare was then already recognised as a first-class playwright and poet; but nevertheless his name appears frequently in the lists placed lower than the names of others. There is certainly no intimation in Meres that Shakespeare was in any way unique, requiring to be classed apart. The subjoined quo-

tations have a bearing on this subject, and are important because they show Shakespeare in a variety of lights:—

“As the Greek tongue is made famous and eloquent by Homer . . . , so the English tongue is mightily enriched, and gorgeously invested in rare ornaments and resplendent habiliments by Sir Philip Sydney, Spenser, Daniel, Drayton, Warner, Shakespeare, Marlowe, and Chapman. . . . As the soul of Euphorbus was thought to live in Pythagoras, so the sweet witty soul of Ovid lives in mellifluous and honey-tongued Shakespeare, witness his Venus and Adonis, his Lucrece, his sugared sonnets among his private friends, etc. . . . As Plautus and Seneca are accounted the best for Comedy and Tragedy among the Latins, so Shakespeare among the English is the most excellent in both kinds for the stage. [Mentions Titus Andronicus] . . . As Epicius Stolo said that the Muses would speak with Plautus’ tongue, if they would speak Latin, so I say that the Muses would speak with Shakespeare’s fine-filed phrase, if they would speak English. . . . As Horace says of himself, *Eregi monumentum ære perennius*, . . . so say I severally of Sir Philip Sydney’s, Spenser’s, Daniels’, Drayton’s, Shakespeare’s, and Warner’s works. . . .

“ . . . [The best lyric poets are] Spenser, Daniel, Drayton, Shakespeare, Bretton. . . . Our best for Tragedy, Lord Buckhurst, Dr. Leg, Dr. Edes, Master Edward Ferris, the author of the *Mirror for Magistrates*, Marlow, Peele, Watson, Kyd, Shakespeare, Drayton, Chapman, Dekker, and Benjamin Johnson. . . . The best for Comedy amongst us be, Edward Earl of Oxford, Dr. Gager, Master Rowley, Master Edwardes, eloquent and witty John Lilly, Lodge, Gascoyne, Greene, Shakespeare, Thomas Nash, Thomas Heywood, Anthony Mundy our best plotter, Chapman, Porter, Wilson, Hathway, and Henry Chettle. . . . These are the most passionate among us to bewail and bemoan the perplexities of love, Henry Howard Earl of Surrey, Sir Thomas Wyatt the elder, Sir Francis Brian, Sir Philip Sydney, Sir Walter Rawley, Sir Edward Dyer, Spenser, Daniel, Drayton, Shakespeare, Whetstone, Gascoyne, Samuel Page, Churchyard, Bretton.”

Shakespeare was not the sole successor to his predecessors. On the contrary, there were a large number of successors, and the evolution of the finer and superior type of play continued. As a plain fact, there is nothing to suggest that Shakespeare alone improved on the earlier dramatists, or that the other dramatists were only servile imitators of his work. From all the evidence at our disposal, we are forced to believe that Shakespeare was classed with the other playwrights, and though considered to be among the best, no one thought of proclaiming him sovereign or greatly superior to all the others. The following quotation from Webster’s Preface to his *White Devil* well illustrates the general attitude of his age towards him:—

“Detraction is the sworn friend to ignorance: for mine own part, I have ever truly cherished my good opinion of other men’s worthy labours: especially of that full and heightened style of Master Chapman; the laboured and understanding works of Master Jonson; the no less worthy composures of the both worthily excellent Master Beaumont and Master Fletcher; and lastly (without wrong last to be named), the right happy and copious industry of Master Shakespeare, Master Dekker, and Master Heywood.”

On the negative side there is abundant evidence to prove that, in his time, Shakespeare was not regarded as paramount among dramatists. This view may appear to be in flagrant

contradiction with the commemorative verses of Ben Jonson and of others prefixed to the first Folio, which verses would lead one to assume that his leadership was generally recognised. However, when we find that there were far more numerous poems of the same kind published at the death of Ben Jonson, and also in connection with the first Beaumont and Fletcher Folio, it becomes manifest that either the judgment passed on Shakespeare changed, which is a somewhat gratuitous assumption, or that commemorative verses were apt to be couched in superlatives. Here are a few examples culled to illustrate the above, the first referring to Ben Jonson:—

“Great Jonson, king of English poetry.”

“... wit's most triumphant monarch ...”

“Look up! where Seneca and Sophocles,
Quick Plautus and sharp Aristophanes,
Enlighten yon bright orb! doth not your eye,
Among them, one far larger fire descry,
At which their lights grow pale? 'tis Jonson, there
He shines your Star, who was your Pilot here.”

“One still will spin, one wind, the other cut,
Yet in despite of spindle, clue and knife,
Thou, in thy strenuous lines, hast got a life,
Which, like thy bay, shall flourish every age,
While sock or buskin move upon the stage.”

“Though (to our grief) we ever must despair,
That any age can raise thee up an heir.”

“Who without Latin helps hadst been as rare
As Beaumont, Fletcher, or as Shakespeare were.”

“Though there be many that about her brow,
Like sparkling stone, might a quick lustre throw;
Yet, Shakespeare, Beaumont, Jonson, these three shall
Make up the gem in the point vertical.”

“Poet of princes, prince of poets ...”

“Shakespeare may make grief merry, Beaumont's style
Ravish and melt anger into a smile;
In winter nights, or after meals they be,
I must confess, very good company;
But ...”

“The marble glory of thy laboured rhyme
Shall live beyond the calendar of time.”

“Thou shalt be read as classic authors; and,
As Greek and Latin, taught in every land.”

“That Latin he reduced, and could command
That which your Shakespeare scarce could understand?”

And hear the encomiums passed on Beaumont and Fletcher, more particularly on the latter:—

“When Jonson, Shakespeare, and thyself did sit,
And swayed in the triumvirate of Wit.
Yet what from Jonson’s oil and sweat did flow,
Or what more easy nature did bestow
On Shakespeare’s gentle muse, in thee full grown
Their graces both appear.”

“Fletcher (whose fame no age can ever waste;
Envy of ours, and glory of the last).”

“Shakespeare to thee was dull . . .”

“None writes love’s passions in the world like thee.”

“Brave Shakespeare flow’d, yet had his ebbings too,
Often above himself, sometimes below;
Thou always best.”

“Fletcher, the king of poets.” . . .

“Thou grew’st to govern the whole stage alone.”

Such was the verdict on Shakespeare, we may say, up to the year 1642, when the stage suffered a complete eclipse which lasted some eighteen years. A new world had been born when the theatres were reopened after this prolonged and gloomy pause. A whole generation had grown up without seeing any plays performed, and the memory of the playgoers must have been greatly dimmed, especially as the interval was crowded with exciting political events. But this was only a minor matter. The Court had returned from France, where Corneille deservedly ruled the stage, imbued with classic notions regarding the structure and contents of plays, notions which were in rather violent contradiction with the “lawlessness” which characterised the Elizabethan dramatists who knew nothing of the unities of time, space, and plot, and the rigid separation of tragedy from comedy. To the anti-puritans, too, the theatrical fare proffered by the Elizabethan playwrights—far too strong for us—was looked upon as decidedly puritanical. Accordingly, a radical re-valuation of values took place, and the Elizabethan stage seemed as if it belonged to antiquity, and this was emphasised by the development of higher and more fastidious literary standards. Lastly, interest in music generally, and the opera in particular, helped to divert the attention from the Elizabethan dramatists.

In these circumstances only what was quite exceptional would tend to escape the clutches of oblivion: broadly speaking, Shakespeare, Ben Jonson, and Beaumont and Fletcher. From that age we have Dryden’s *Essay on Dramatick Poesy*. In this work Jonson largely monopolises the space, Beaumont and Fletcher are fairly frequently referred to, and Shakespeare

comparatively rarely. And yet, whilst by implication paying deeper homage to Ben Jonson, and informing us that Beaumont and Fletcher were greater stage favourites than Shakespeare, two of their plays being performed for one of Shakespeare's, a panegyric on Shakespeare appears which certainly is the turning point in the fortunes of Shakespeare's fame. However, the praise bestowed is hesitating. Summoning courage, Dryden introduces the often quoted passage relating to Shakespeare, by the following remark: "It will be still necessary to speak somewhat of Shakespeare and Fletcher, [Ben Jonson's] rival in poesy; and one of them, in my opinion at least, his equal, perhaps his superior." (Ed. 1668, p. 47.) Dryden was, in fact, in no sense an idolater, as witness the following passage: "I cannot say he is everywhere alike. . . . He is many times flat, insipid; his comic wit degenerating into clenches, his serious swelling into bombast." (Pp. 47-48.) "Shakespeare's language is likewise a little obsolete."

A little later, in 1674, Edward Phillips, Milton's nephew, in his Dictionary of Poets, speaks of a triumvirate consisting of Ben Jonson, Fletcher, and Shakespeare, each excelling in certain directions.

To the end of the seventeenth century, there was no progress towards the recognition of Shakespeare's supremacy and uniqueness. Before its close, Thomas Rhymer, who had already unceremoniously examined Beaumont and Fletcher, turned his attention to Shakespeare, and, in the same spirit, severely criticised Shakespeare for a variety of defects in his dramatic works, singling out Othello and Julius Cæsar for dissection. The eighteenth century repudiated Rhymer's negative attitude, but accepted his criticism almost in its entirety. From Dryden, until after Samuel Johnson, for approximately a century, the editors and champions of Shakespeare tempered their enthusiasm with a scathing critique which would appear to most Shakespeareans of to-day little short of blasphemous. Pope, one of Shakespeare's first editors, did not mince his words, as the following extracts from his edition of Shakespeare's works show:—

"For of all English poets Shakespeare must be confessed to be the fairest and fullest subject for criticism, and to afford the most numerous, as well as most conspicuous instances, both of Beauties and Faults of all sorts. . . . It must be owned that with all these great excellencies, he has almost as great defects; and that as he has certainly written better, so he has perhaps written worse, than any other. . . . With all his faults, and with all the irregularity of his drama. . . . Nor does the whole fail to strike us with greater reverence, though many of the parts are childish, ill-placed and unequal to its grandeur."

So Dr. Johnson, in the Preface to his edition of Shakespeare:—

"In tragedy he often writes with great appearance of toil and study, what is written at last with little felicity; but in his comic scenes, he seems to produce without labour, what no labour can improve. In tra-

gedy he is always struggling after some occasion to be comic, but in comedy he seems to repose, or to luxuriate, as in a mode of thinking congenial to his nature. In his tragic scenes there is always something wanting, but his comedy often surpasses expectation or desire. . . . His tragedy seems to be skill, his comedy to be instinct."

"Shakespeare, with his excellencies, has likewise faults, and faults sufficient to obscure and overwhelm any other merit."

"The plots are often so loosely formed that a very slight consideration may improve them, and so carelessly pursued, that he seems not always fully to comprehend his own design."

"In his comic scenes he is seldom very successful, when he engages his characters in reciprocations of smartness and contests of sarcasm; their jests are commonly gross and their pleasantry licentious; neither his gentlemen nor his ladies have much delicacy, nor are sufficiently distinguished from his clowns by any appearance of refined manners."

"In narration he affects a disproportionate pomp of diction and a wearisome train of circumlocution, and tells the incident imperfectly in many words, which might have been more plainly delivered in few."

And much more to the same effect.

In 1709 Rowe published an edition of Shakespeare's plays in a number of volumes, prefacing it with a life of the author. This "life", mostly based on traditions, did much to direct attention to Shakespeare, and to spread his fame. We observe here an interesting psychological reaction. The emphasis on Shakespeare's humble origin and reputed lack of learning magnified by contrast his dramatic achievements, and fixed men's regards on him. His deficiencies cried out for an explanation and evoked sympathy. They attracted scholars to the interesting task of elucidating the work of that precocious child of nature.

A series of critical editions of Shakespeare's plays was the result, all introduced by very readable prefaces. The latter dilate on Shakespeare's genius, but also on his ignorance of the classics, his frequent lapses, his numerous imperfections, and the corruptions and obscurities of the text of his plays. The comparison is always between Shakespeare and the ancients, and references to other Elizabethan playwrights are not only extremely rare, but there is every indication that, apart from Ben Jonson and Beaumont and Fletcher, the plays of the Elizabethans were unknown, copies of their works being probably inaccessible to the editors in those days when there were no great public libraries. In this we are supported by the fact that all the high qualities which Dr. Johnson ascribes to Shakespeare are qualities generically distinguishing the Elizabethan and Jacobean drama.

Eighteenth century England found its energies only equal to the task of critically studying one author, the number of competent scholars being presumably too small to attempt the further task of doing justice to other Elizabethan dramatists. Several editions of Beaumont and Fletcher were published during the century, but scholarship had no time left for examining the works of these authors.

The succession of Shakespeare editors kept Shakespeare alive, and contributed indirectly towards burying the other Elizabethan playwrights. This double action had another serious consequence. The already appreciated Shakespeare found a still more effective populariser in Garrick, the intellectual actor-manager. What the scholars planted, he brought to fruition, the limelight of the stage incidentally still further obscuring the neglected Elizabethans.

Criticism had done its best or worst, and scholars turned from criticism to appreciation. Here was ample scope for the analytic faculty and for literary taste. With the other Elizabethan dramatists many feet below the soil of time, Shakespeare's plays appeared justly so marvellous that criticism—carping or judicious—ceased, and the present-day wholehearted Shakespeare worship was slowly ushered into the world.

However, Shakespeare was destined to find his greatest admirers abroad. The growing romantic movement of the later eighteenth century in Germany was irresistibly attracted to Shakespeare, and since the Elizabethan dramatists generally, and the subsequent English criticism, were unknown to the Germans, they could abandon themselves to unrestrained idolatry. Germany is thus said to have "discovered" Shakespeare; England, with Charles Lamb, Coleridge, and Wordsworth, rather tamely and lamely following.

Charles Lamb, in his *Specimens of the English Dramatic Poets*, sought to direct attention to the priceless treasures embedded in many of the Elizabethan playwrights, and opened thereby a new era. The pendulum, however, had swung too far away from the centre of sanity. Shakespeare having become men's idol, any resemblance to him was regarded as puerile imitation, and any difference as an unwarrantable departure from the ideal norm. Accordingly, Shakespeare, contrary to the views marking his own age and those of the leading literary men of the eighteenth century, was regarded as incomparable and as infinitely superior to the other Elizabethan playwrights. Lamb's example exercised little influence, and Swinburne's later series of appreciations were widely ignored or discounted. The comparative method was hence almost entirely neglected. For all intents and purposes, for instance, Sir Sidney Lee's *Life of Shakespeare*, the articles on Shakespeare in the *Dictionary of National Biography*, and the chapters on Shakespeare in the *Cambridge History of English Literature*—that is, our leading sources in Shakespeare criticism—ignore the comparative method. For these writers, and they are strictly typical of our time, with the laudable exception of Professor Ward, Shakespeare lived and wrought as if no other playwright of any distinction had existed in his day.

We perceive that there is a very slender factual basis for this extraordinary attitude in our generation towards Shakespeare

and his fellows. His own time did not think of singling him out as overwhelmingly superior and altogether different, nor did the remainder of the seventeenth century. The first seventy years of the eighteenth century recognised numerous limitations in Shakespeare, and made no attempt at a comparative study of the Elizabethan dramatists. The Germans of the same century were without the necessary material for forming a discriminating judgment. And, similarly, the view prevalent to-day is equally not the result of a sober, or even tentative, comparative estimate of Shakespeare and his fellows.

We have therefore no reason for surmising that the present verdict on Shakespeare will be the final verdict of history. For example, whilst Shakespeare is regarded as unapproachable, and towering sky-high above his fellows, we are presented with the ludicrous spectacle of interminable discussions as to whether a play or a part of a play attributed to Shakespeare is his. Some critics, for instance, assert that certain portions of *The Two Noble Kinsmen* could only have been written by Shakespeare, whereas other orthodox Shakespeareans deny this flatly. On the other hand, parts of *Henry VIII.*, which had been singled out as characteristic of Shakespeare at his best, are now admitted to be by another playwright. Over a dozen plays of Shakespeare have thus given rise to keen discussions regarding the genuineness of certain portions thereof, without a clear, let alone an instantaneous, verdict on the issue having been arrived at. The doctrine of the uniqueness of Shakespeare may be therefore an irrational dogma that has no relation to fact, and is possibly due to comparatively uncritical thought and feeling which further study is bound to destroy.

The final pronouncement of history cannot far depart from the estimate of his time. We ought to think of Shakespeare as belonging to a great age, and as, on the whole, expressing it slightly better than his fellow dramatists, whilst not unfrequently falling below the others, and fairly frequently having his best equalled. From the scientific standpoint the glory belongs first and foremost to the Elizabethan drama as such, or even more to his times which were directly responsible for evoking this outburst of unparalleled dramatic splendour. Critically considered, scarcely a characteristic in Shakespeare can be mentioned which is not a characteristic of his time and his fellow playwrights. The glowing panegyric extending over several pages, which Johnson, in the Preface to his Shakespeare edition, pronounced on Shakespeare, would hold true no less of Beaumont and Fletcher and a number of other Elizabethan and Jacobean playwrights. Another apt illustration is to be found in Robert Greene's *James the Fourth*, published anterior to any of Shakespeare's plays, which offers a surprising example of what is said to be most distinctive of Shakespeare. Verse, plot, motivation, men, women, humour, poetry, insight, philo-

sophy, are exact anticipations of Shakespeare, and, but for the unavoidably primitive verse and its consequences, the play is superior to sundry of Shakespeare's earlier works.

Shakespeare soars immeasurably above what our present-day drama offers, because our drama is immeasurably inferior to the drama of Shakespeare's time. What has been asserted of his plays by perfervid admirers is roughly correct; but the true author of these plays was an age, and not an individual. This explains why his age failed to take our age's view of Shakespeare, and why he himself appeared to be unconscious of greatness, and lived and died conventionally.

The Shakespeare problem offers accordingly a superb illustration of the indispensability of an exhaustive study of facts when a serious issue is to be elucidated, and the fatal effects of striving to remove difficulties by speculative considerations.

§ 24. Where, then, a process is highly complex, such as that of observation, the doctrine of method must needs frame or discover canons which shall effectively deal with this process. Else the other canons will be infected at the source. The perfection of the process of observation should be conceived accordingly as the corner stone of the correct method of investigation.¹ Scientific advance has meant keener and keener, closer and closer, wider and wider, more and more varied, observation. Of course, *where much scientific observation has preceded the initiation of an enquiry into a certain subject, we may postulate much; and it is exceptional illustrations, drawn from highly developed and simple sciences, which have deluded men into thinking that it is safe and profitable to generalise on the basis of comparatively few instances.* The opposite cases are disregarded where observation imposes a gigantic task in a novel enquiry, rendering it impossible to generalise even tentatively, save after exceedingly wide and varied observation by many persons under changing conditions of time, place, motive, habit, or other circumstances.

If what appears to us a "natural" object is—as we have learnt in the preceding Section—a highly "artificial" and largely arbitrary product of the mind, it is truer still that observation, whose scope is much ampler, entails as a rule extensive mental activities. *We might define the process of observation as that part of an enquiry which aims primarily at the accurate determination of detailed facts.* If many logicians only burn incense before the altar of deduction, and reason that a bold guess and subsequent verification represent the true method of science, a study of contemporary scientific procedure will convict them of being idolaters. As a matter of fact, the weather-stained bones of slain theories, which thickly strew the fields of history, should make

¹ "We are not to imagine or suppose, but to discover, what nature does or may be made to do." (Bacon, *Novum Organum*, bk. 2, 10.)

it evident that nothing is gained and everything is hazarded by obstinately clinging to a superstition wofully at war with reality. The further science advances, the more patent it will become that it is capital folly to ground a generalisation on aught but exhaustively studied data.

The leading facts of nature are complex beyond anything anticipated by those who extol to the heavens the deductive method. Take, for example, the effect of the radiant heat of the sun on the different surfaces whereon it strikes. "The greatest contrasts are found between land and water surfaces. If the solar radiation fall on a water surface, the absorption in the uppermost layers of the water is not nearly so complete as is the case with a land surface. The water is transparent to some of the radiation which therefore passes through it to be gradually absorbed by the lower layers. The heat is thus more widely distributed, and the rise of temperature in the surface layers is proportionately reduced. Still more important is the fact that water has a much greater so-called specific heat than soil or rock—that is to say, a much greater amount of heat has to be absorbed by a pound of water than by a pound of earth to produce a given rise of temperature. The net result is that the surface layer of the water is warmed very much less than the land surface, and, as a result, the air above the water is also warmed to a less degree. On the other hand, at night time, a water surface radiates less heat into space than a land surface under similar circumstances would do. Moreover, any cooling which may take place at once calls into play convection processes in the water itself. The cooled water becomes more dense and sinks, and warmer water from below takes its place. Thus there is a great tendency for a water surface to remain at a more or less constant temperature both by day and by night, and for the changes of temperature due to changes of season to be reduced in magnitude. This difference in the behaviour of a water surface and a land surface has a most important climatic effect. . . ." (R.G.K. Lempfert, *op. cit.*, pp. 16–17.)

Even more striking is the fact of hibernation, since it demonstrates the folly of rash generalising and abstract deductive reasoning:—

"As far as mammals are concerned, the following are the principal facts established: (1) All northern species, even those which find food scarce during winter, do not hibernate, nor do all the species of the same family, order, or genus. Even both sexes of the same species do not always agree in this respect. The bear, the badger, the dormouse, the hamster, the bat, the marmot, the zizel, and the hedgehog are among the best known and most pronounced hibernators. But while all the burrowing marmots, whistlers, woodchucks, ground-hogs, etc., are more or less complete hibernators, the Alpine marmots indulge in this habit by fits and starts. The sloth bear and other Indian *Ursidæ* differ from the other members of their family in remaining awake during winter, though they are sluggish during this season, moving about very little, and then only occasionally when they require food; and both the black and brown bear of the Rocky Mountains and the polar bear are strict hibernators only as regards their females, the male being often seen at large between November and May. Most of the American squirrels differ from the European species in being non-hibernating. (2) The same animal may vary in this respect in different portions of its range. Thus, though the American skunks are in the northern part of the region over which they roam more or less complete hibernators, they get more and more wakeful as their range extends equatorially, until in the most southern part of it they move about freely at all seasons of the year. In like manner, the prairie 'dog', or marriot, in the northern plains retires to sleep during severe weather, as do also the woodchucks of the same region, but in open winters and on pleasant days they display no such tendency; while in the extreme southern limits of their range they are not hibernators

at all. (3) They do not all retire at the same time. Most of the true hibernators take to their 'hibernaculum', or winter hole—a burrow, a hollow tree, a cave, the eaves of a house, or similar situation—in late autumn, varying the date slightly according to weather. But the great bat is rarely seen after September, and often retires as early as the end of July, when its insect food is abundant. (4) All of them do not sleep the same length of time, or with the same torpidity, and several indulge in hibernation and waking alternatively during the winter. The squirrel, in Britain, lies dormant most of the cold season; but on sunshiny days it often wakes, visits its hoards of food, eats freely, and then retires to rest again. The hedgehog is sometimes seen during the winter; and on sunshiny days the common bat often emerges from its hibernaculum, and flits about even when snow is on the ground. The dormouse also at intervals wakes up, eats, and goes to sleep. Other animals, like the long-tailed field-mouse, pass the winter in a drowsy state not far removed from dormancy. There are thus all gradations between continuous winter dormancy and the ordinary daily sleep of a few hours in which every animal indulges. There is also every degree of torpidity exhibited. The hedgehog and the dormouse may be rolled over and over like a ball, without waking, and the black bear of America is extremely difficult to arouse out of its winter sleep. On the other hand, the brown bear of Siberia hibernates lightly, and is very dangerous when awakened. The hedgehog, if disturbed, 'takes a deep sonorous inspiration followed by a few feeble respirations, and then by total quiescence'. This differs from the stirring and then coiling itself up again which is the animal's way when awakened out of an ordinary sleep. But, though sensation and volition are dormant, the reflex and excitomotor actions are keen, the slightest touch applied to the spine of a hedgehog or to the wings of a bat inducing one or two inspiratory movements. But the hibernating badger is not difficult to reawake, and in its torpor, like all hibernating animals, is not rigid. (5) Continuous hibernators do not lay in stores of food. Intermittent winter-sleepers generally do, while some animals which are not true hibernators, but remain only drowsy during the winter, retire to their burrows to pass the days of famine above ground amidst their abundant nuts and other provender. All of these food-storers are vegetable-eaters. The arctic fox is indeed the only exception to this rule, for though it is not any more than the beaver a hibernator, it hoards up dead lemmings, ermines, geese, hares, etc., against the evil days of winter. An exception to intermittent hibernators being thus provident is afforded by the porcupine and the alpine marmot." (*Chambers' Encyclopædia*, article "Hibernation", by Robert Browne.)

An eloquent defence of observation as an invaluable scientific asset is contained in a paper on "The Characteristics of the Observational Sciences", which was read before the British Association in 1911 by Prof. H.H. Turner, President of the Mathematics Section. Prof. Turner admirably expresses the point of view we adopt:—

"The perception of the need for observations, the faith that something will come of them, and skill and energy to act on that faith—these qualities, all of which are possessed by any observer worthy the name, have at least as much to do with the advance of Science as the formulation of a theory, even of a correct theory. The work of the observer is often forgotten—it lies at the root of the plant; it is easier to notice the theories which blossom, and ultimately produce the fruit. But without the patient work of the observer underground there would be neither blossom nor fruit."

SECTION X.—EXPERIMENT AND USE OF INSTRUMENTS.

§ 25. A decided approach towards experiment is made where an action is intentionally performed in order to ascertain the results—where, for instance, I seek to recall a landscape for the purpose of observing what can be recalled; where I shut my eyes to note whether anything is visible with eyes closed; where I pull at a heavy piece of furniture to study the nature of the feeling of effort; where I pinch myself to learn something concerning pain; where, with one hand, I play with two pebbles for some time, throwing them successively up into the air, and endeavour to catch them in the same hand as they fall, in order to learn something of the development of a habit; where I speak now gently and now sternly to a child, to the end of determining which course is the most effectual; and so on.

Experiments of this order are unsystematic in nature, and the proof lacks exact determination. They are experiments belonging to the pre-scientific stage, and only become veritably trustworthy when the conditions are clearly defined and systematically varied. *Scientific experiment*, in other words, is *systematic observation under conditions as far as possible precisely defined and systematically varied and measured*. When, for example, we combine certain known chemical elements present in a known proportion by means of special apparatus which enables us to obtain exact quantitative results, we experiment, in the scientific sense of the term.¹ The value of such quantitative determination is often one of indirect importance, inasmuch as its object may be to lend precision to a statement which might aid us in obtaining reliable deductions.

Pre-scientific experiments have, as a rule, relatively small scientific value. On the other hand, methodical observation closely approaches scientific experiment. To examine a plant species in the sunlight, in the shade, at night, when it is raining, in varying temperatures, soils, altitudes, and climates, and at different seasons, is virtually equivalent to producing the conditions artificially. It was, therefore, an inadequate conception of the process of observation which condemned observation as being wellnigh useless and unscientific, whilst lauding to the skies the employment of experiment. The genuine comparison is between pre-scientific observation and pre-scientific experiment; and if this be conceded, indiscriminate contempt for observation is as gratuitous as indiscriminate commendation of experiment.² Scientific experiment forms an

¹ Jevons has several excellent chapters on quantitative determination in his *Principles of Science*.

² "At Greenwich Observatory in the present day, the hundredth part of a second is not thought an inconsiderable portion of time. The ancient

extension of scientific observation, and constitutes really only a refinement thereof. As a matter of fact, the more conclusive kind of experiment is of recent origin, and many of the historic truths have been reached by rough trials. Newton's investigations into the nature of light were not conducted by means of elaborate apparatus. Franklin's kite or his pieces of variously coloured cloths do not suggest modern experiments; and Darwin's delightful study was anything but an up-to-date laboratory.

The special object of methodical experiment is to obtain assured knowledge of quantity, properties, cause and effect,

Chaldeans recorded an eclipse to the nearest hour, and the early Alexandrian astronomers thought it superfluous to distinguish between the edge and centre of the sun." (Jevons, *Principles of Science*, p. 271.) Psychologists now resort to chronometers indicating the one-thousandth part of a second. The best telescopes reveal a hundred million stars where sight disclosed only about eight thousand, and where, with the aid of auxiliary photographic processes, a thousand million may be registered. Spectrum analysis records the 400-millionth of a grain. A good balance, containing in each pan about a kilogramme, will indicate a difference of one-ten-thousandth of a grain. The most efficient measuring machines will measure the millionth part of an inch. There is literally no term to the refinement of instrumental measurement. Where the unassisted eye detected a little over half a dozen planets, five hundred are now known. With platinum resistance thermometers "at ordinary temperatures the difference of temperature of one-ten-thousandth of a degree can be deducted with moderate ease, while, with great precautions, the hundred-thousandth of a degree can be estimated". (Whetham, *The Recent Development of Physical Science*, 1906, p. 71.)

"Ordinary microscopical observation with the strongest lenses can show particles of about $250\ \mu\mu$ in diameter. We call particles of and above this size *microns*. The ultramicroscope makes particles visible even down to the size of $6\ \mu\mu$, provided that the power of light applied is strong enough. Such particles are called *submicrons*." Those below this size are named *amicros*. (Frederick Czapek, *Chemical Phenomena in Life*, 1911, pp. 25-26.) "Microtomes of the best workmanship have placed in the hands of histologists the means of making serial sections of remarkable thinness and regularity." (W. A. Locy, *op. cit.*, p. 438.) "With our present instruments we can perceive lines ruled on glass which are $1/90,000$ of an inch apart. ... If ... we could use the blue rays by themselves, their waves being much shorter, the limits of possible visibility might be extended to $1/120,000$." (C. S. Minot, *The Problem of Age, Growth, and Death*, 1908, pp. 189-190.)

"The number of rods and cones in the human eye is enormous. At a moderate computation the cones may be estimated at over 3,000,000, and the rods at 30,000,000. (Lord Avebury, *On the Senses, Instincts, and Intelligence of Animals, with special reference to Insects*, p. 123.) "Though not thicker than a sheet of thin paper, [the retina] consists of no less than nine separate layers." (*Ibid.*, p. 122.) "According to the view of Helmholtz, the smallest particle that could be distinctly defined, when associated with others, is about $1/80,000$ th of an inch in diameter. Now, it has been estimated that a particle of albumen of this size contains 125,000,000 of molecules. In the case of such a simple compound as water, the number would be no less than 8,000,000,000." (*Ibid.*, p. 190.)

"If we imagine a number of hydrogen molecules placed end to end, it would require fifty millions of them to form a row one centimeter in length." (W. C. McC. Lewis, "The Structure of Matter", in *Science Progress*, January, 1918, pp. 477-478.)

relations, presence or absence of particular substances, etc.,¹ and in devising such experiments the utmost precautions are required to secure a decisive result free from all complications and entirely unequivocal. *A scientific experiment of a high order may be defined as consisting of observation or registration of a methodical character by means of carefully constructed apparatus under deliberately selected and varied conditions.*²

Experiment, for instance, of a non-instrumental character, but not less rigorous, is urgently needed in certain departments of natural history. Books without number have been published concerning the mentality of animals, and yet certainty in this matter completely escapes us. What is required is systematically to observe dogs, cats, fowl, and other domesticated animals, common birds, etc., preferably one male and one unrelated female together (in order to include activities connected with the perpetuation of the species and the rearing of offspring) from birth to a natural death, in an environment where no other members of the same or closely related species exist in the vicinity, and to chronicle faithfully and intelligently the behaviour of the individuals thus isolated. It seems almost

¹ For a list of the general characteristics of phenomena, see the Table of Primary Categories in Conclusion 3.

² "Experience may be acquired in two ways: either, first, by noticing facts as they occur, without any attempt to influence the frequency of their occurrence, or to vary the circumstances under which they occur; this is Observation; or, secondly, by putting in action causes and agents over which we have control, and purposely varying their combinations, and noticing what effects take place; this is Experiment." (Sir John Herschel, *Discourse*, [67.]) "Passive and active observation might better express their distinction." (*Ibid.*)

"Observation is finding a fact, experiment is making one." (Bain, *Logic*, vol. 2, p. 43.)

"When we merely note and record the phenomena which occur around us in the ordinary course of nature we are said to observe. When we change the course of nature, by the intervention of our muscular powers, and thus produce unusual combinations and conditions of phenomena, we are said to experiment. . . . Experiment is thus observation plus alteration of conditions." (Jevons, *Principles of Science*, p. 400.) "One of the most requisite precautions in experimentation is to vary only one circumstance at a time, and to maintain all other circumstances rigidly unchanged." (*Ibid.*, p. 422.) "One of the great objects of experiment is to enable us to judge of the behaviour of substances under conditions widely different from those which prevail upon the surface of the earth." (*Ibid.*, p. 426.)

"Experiment is the practical means by which we furnish ourselves with observations in such number, and involving such mutual differences and affinities, as is requisite in order to the elimination of what is unessential in them and the derivation from them of a pure case." (Lotze, *Logic*, vol. 2, pp. 39-40.)

"Scientific experiment, therefore, is scientific observation performed under accurately known artificial conditions." (Huxley, *Introductory*, 1900, p. 17.)

"Experiment is observation under artificial conditions." (Bosanquet, *Logic*, vol. 1, p. 143.) "Experiment would usually be considered to begin where we pass from intentional selection of our standpoint, and from the use of contrivances auxiliary to perception, to actual analytic interference with the object under observation." (*Ibid.*, p. 143.)

impossible to believe—which incidentally and pointedly proves the absence of an accepted methodology—that this should not have been accomplished already. Once numerous observational experiments of this character have been completed, and the general mentality of the species has been ascertained, the situation could be complicated by subjecting the animals to artificial tests.

Instruments are not indispensable to experiment, though little can be achieved without them. Galileo, in his experiments from the leaning tower of Pisa, employed no specially devised instruments, and many experiments in agriculture and legislation, and in other departments of knowledge, are executed without their assistance. Not a few of Darwin's experiments possessed a homely character, and Galton's famous enquiry relating to mental imagery was markedly simple and non-instrumental.¹ On the other hand, microscopes, telescopes, spectroscopes, and a multitude of other aids, are employed in observation, since instruments multiply the power and the delicacy of the senses almost an infinite number of times.² We may, consequently, distinguish between instrumental and non-instrumental observation and experiment. In observation neither the object observed nor its environment would be designedly altered; in experiment one or both would be affected. Instruments, again, may be divided into scientific and non-scientific ones. *Scientific instruments are such as are carefully calculated to attain the end aimed at in an easy, an exact, and a measurable manner.* Non-scientific instruments more or less lack these qualifications. Determining the weight of a substance by weighing it respectively in the hands and on a tested and sensitive pair of scales, may fix the distinction between the two. It is somewhat difficult to define use and non-use of instruments. For practical purposes, however, the above definition of instrument is passable, especially when it is a question of scientific instruments. Similarly the meaning of change in object and environment is only subject to a minimum of misconception, because our presence, for instance, may be readily discounted: our weight; shadow thrown; the air altered

¹ According to the *Encycl. Brit.* (11th ed.), so distinguished a modern physicist as Lord Rayleigh did not despise simple experiments: "The experimental investigations are carried out with plain and usually home-made apparatus, the accessories being crude and rough, but the essentials thoughtfully designed, so as to compass in the simplest and most perfect manner the special end in view."

² Interesting chapters on the use of instruments will be found in Jevons and Venn. We shall cite a certain modern instrumental mode of procedure because of its important bearings in palæontological enquiry. "By means of spreading mucilage and tissue paper over delicate bones that crumble on exposure to the air, and the wrapping of fossils in plaster casts for transportation, it has been made possible to uncover and preserve many structures which, with a rougher method of handling, would have been lost to science." (W. A. Locy, *op. cit.*, p. 340.)

and agitated through our moving, breathing, and speaking; diffusion of bodily warmth; and the like circumstances. These are, in any case, not deliberately produced transformations, and are generally not impossible to guard against when we are aware of them.¹

Direct experiments cannot be resorted to in all forms of enquiry, as, for example, in astronomy or generally in geology. Nor are they everywhere equally profitable. In the biological sciences, where not only the same object differs materially at different times and differs conspicuously from nearly related objects—the protein of no two species appears to be identical in composition, but where interrelations and interactions of a most complicated order obtain, as illustrated, for instance, by the cerebro-spinal system in man, experiment is at a decided disadvantage, and its results are frequently found to be of questionable value. On the other hand, where, as in mechanics and chemistry, the material investigated is, relatively to life forms, homogeneous in character, experiment achieves its most signal triumphs. For the same reason, experiment becomes progressively more profitable as the material investigated is simplified through accumulated discoveries, whereas its value diminishes in proportion as the amorphous mass of primitive fact and fancy is unsifted. These limitations to experimental enquiries should warn the methodologist against presuming that experiment can be applied ubiquitously, and that it is in all circumstances alike of telling benefit; and, more than this, a survey of the sciences should convince him that an extensive domain exists at present where observation, with or without instruments, is resorted to on a comprehensive scale and with eminently gratifying results. Indeed, in many directions—as in map and chart construction—the information required is derived, solely almost, from exhaustive observation and measurement.

Bacon had a just conception of experiment, and incessantly had recourse thereto. What could be more complimentary to those who believe in addressing pointed questions to nature than this? “The subtlety of experiments is far greater than that of the sense itself, even when assisted by exquisite instruments; such experiments, I mean, as are skilfully and artificially devised for the express purpose of determining the point in

¹ Venn, in his *Logic*, pp. 416–417, says on this subject: “Our bodies are heavy, and, therefore, the mere approach to the machine has altered the magnitude and direction of the resultant attraction upon the scales. Our bodies are presumably warmer than the surrounding air; accordingly we warm and therefore lighten the air in which the scales hang, and if the two scales and their contents are not of the same volume we at once alter their weight as measured in the air. Our breath produces disturbing currents of air. Our approach affects the surface of the non-rigid floor or ground on which the scales stand, and produces another source of disturbance, and so on through the whole range of the physical forces.”

question. To the immediate and proper perception of the sense, therefore, I do not give much weight; but I contrive that the office of the sense shall be only to judge of the experiment, and that the experiment itself shall judge of the thing." (*The Great Instauration, Plan of the Work*; vol. 4, p. 26, of Spedding's edition of Bacon's works.)

The confusion enveloping the subject of experiment in relation to observation is due, we should remember, to historical causes. The modern idea of scientific observation is the product of a protracted evolution. None of the ancients, not even Lucretius, suspected the complexity of the process. To observe with microscopic minuteness, for a prolonged period, under exhaustively varying circumstances of space and other conditions, was only slowly suggested by historic experience, so much so that even now our conception of observation grows in profundity with every decade. Moreover, the instruments which greatly increase our powers of observation are a comparatively recent and still growing acquisition, just as the lack, danger, and impossibility of extensive intercommunication over prodigious distances, narrowly limited an enquiry. So with experiment. To Roger Bacon, the idea of appealing to experience appeared to embody a high methodological ideal, and the notion of *experiment* was scarcely distinguished from *experiencing* even by Leonardo da Vinci.¹ Experience itself had only partially the objective character we attribute to it to-day. Similarly, the modern idea of a scientific experiment has a long history. In Francis Bacon's time it had already developed to no mean degree, as is illustrated by Gilbert's treatise, *De Magneto*, and by Galileo's labours generally. And since his day, both on the side of method and of instruments, there has been ceaseless improvement. Accordingly, it is futile to examine the subject before us, save in the light of history, in which case the ground is cut beneath the controversy, and mutual appreciation follows mutual recrimination.

SECTION XI.—CAUSAL ENQUIRIES.

§ 26. (a) *Importance of Causal Enquiries.*—The object of science is to determine unequivocally the nature and relations of animate and inanimate objects and of psychic phenomena, and one of the most important relations is unquestionably that of cause. Indeed, to know *precisely* the cause of a phenomenon is to be acquainted precisely with *two* facts—the phenomenon which is the effect and another in so far as it is the cause. Objects of which we do not establish the cause are, as it were, suspended by invisible cords, and the progress of knowledge demands that facts shall not appear isolated. We inquire therefore into the cause of the cohesion and repulsion of particles

¹ J. V. Marmery, *op. cit.*

and masses; of chemical, crystalline, vital, and moral action; of the origin of States and civilisations; of the development of the arts and the appreciation of the beautiful; and we cannot rest satisfied until the causes are made plain to us. At the same time our insight into causes must be exact and relatively exhaustive, if it is to possess scientific validity. Any one may be convinced that he feels hot because he closely faces a coal fire fiercely burning in an open grate, or because he is exposed to the scorching rays of a tropical sun; but such a legitimate conviction leaves him in nearly complete ignorance of his own physical being and of the nature of the coal fire, the sun, or the heat. So, too, nations may empirically discover a tolerably satisfactory diet, or physicians may prescribe dietaries, etc., having decidedly beneficial effects; but the unveiling of the actual causes has revolutionary consequences both in practice and theory. It is only, therefore, when we know precisely and circumstantially the nature of the cause and of the effect of a phenomenon, *e.g.*, the relation of ruminating to cloven hoofs, that we are confronted by a truth which has scientific significance. On this account, the causal aspect is to be regarded as one of a number of indispensable aspects to be examined in any general enquiry.

§ 27. (b) *The Causal View of Nature*.—The causal view of nature conceives the world from the standpoint of time and virtually disregards all other phases. We see, in this panorama, one phenomenon producing a change in another *ad indefinitum*. This is a possible and an important standpoint; but it cannot be said to be the only one possible or of importance. Such a conception involves that we think of facts as consisting of invariable and necessary antecedents and consequents without defining the antecedents and consequents—inquiring, say, into the cause of heat without determining the nature of heat. It misses, that is, the reverse side, the present constitution of the objects which are changing or are to be changed, unless the world is dissolved into featureless forces, which Mill does not contemplate, and which is a barren conception from the angle of the investigator of to-day. The dynamic view of nature must be therefore supplemented by a static view of nature.¹

§ 28. (c) *Static Aspects*.—Since, as we have just seen, science needs be first conversant to a certain degree about phenomena in their quasi-static aspects, before it becomes curious con-

¹ A full discussion of the implications of the term Cause, from the causalistic standpoint, will be found in Mill. According to him "the invariable [or rather "unconditional invariable"] antecedent is termed the cause; the invariable consequent, the effect" (*Logic*, bk. 3, ch. 5, § 2); "the notion of Cause" is "the root of the whole theory of Induction" (*ibid.*); and "to ascertain what are the laws of causation which exist in nature; to determine the effect of every cause, and the causes of all effects, is the main business of Induction; and to point out how this is done is the chief object of Inductive Logic". (*Logic*, bk. 3, ch. 6, § 3.)

cerning their causes, it cannot be said to deal exclusively with the latter. A review of modern science appears to confirm this. The determination of the nature and contents of geological strata; of the distribution of sea and land, of mountain ranges, earthquakes, and of volcanic craters and areas; or the attempt to produce and reduce organic compounds, and ascertain their qualities and their internal arrangement, and to discover the existential relations of the elements; or the efforts to ascertain the composition and the structure of protoplasm, the cell nucleus, and the cytoplasm; or the investigations into the nature of magnetic and electrical phenomena, or those connected with the origin and evolution of life and of human societies—all imply that men of science are frequently employed in discovering and in precisely defining properties, quantities, composition, and the like, of objects, as distinguished from causes.

§ 29. (*d*) *Facts should be studied both Statically and Dynamically.*—When a student examines a phenomenon, he strives to understand it in all its aspects. The relation of this phenomenon to other phenomena, and its origin, development, influence, transformation, and end, form an integral portion of the aim of his study. He who on principle only studied facts statically or dynamically, would represent a caricature of the man of science. Ultimately, therefore, scientific enquiries cannot be divided into static and dynamic ones—those concerned with the discovery of laws of nature and the causal explanation of facts, nor can we, generally speaking, separate static from dynamic fact. The office of the investigator is to comprehend phenomena in all their particularity and bearings, and not only to determine the law of their succession. Mill's insistence on the causal element, to which alone his Canons have reference, is probably due to his eminent predecessor, Herschel, who himself follows Bacon therein. According to Herschel, "the first thing that a philosophic mind considers when any new phenomenon presents itself is its explanation, or reference to an immediate producing cause". (*Discourse*, [137].) But the nature of the "new phenomenon" needs to be determined with fair accuracy before we search for its explanation; else we are ignorant of what it is we are seeking the explanation of.

§ 30. (*e*) *Facts and their Relations.*—The study of a phenomenon entails the study of its relations to preceding, accompanying, and succeeding phenomena. Whatever causes are at work, will be thus laid bare in the course of its examination.

§ 31. (*f*) *Introductory Study of Static Aspects.*—From the foregoing considerations it follows that so long as the principal static elements of a phenomenon are not ascertained, the phenomenon's relations to other phenomena or to its past and future will be almost certainly shrouded in obscurity. Hence the study of causes should be normally preceded by an intro-

ductory study of the chief static aspects of the phenomenon investigated.

§ 32. (g) *Far-reaching Antecedents*.—Finally, we must aim at discovering far-reaching antecedents, because a vast collection of trifling causes is as untractable and unsatisfactory methodologically as a similar number of static facts and generalisations of an equally restricted order. (Conclusion 25.) Science, that is, seeks primarily to discover universal facts, or such as have a high degree of generality: The process of generalisation passed over in Mill's Canons, should enter therefore to a vital extent into the conduct of any causal enquiry.

§ 33. (h) *Study of Effects*.—Nor should we overlook the importance, methodologically, of studying effects, or causes as effects and effects as causes.

§ 34. (i) *The Methodological Meaning of the term Cause*.—It is difficult to over-estimate the value of the discriminations precipitated in names. Men have reasoned ever since the dawn of humanity's career, and animals, in fact, also reason. But it is one thing, in a desperate way, to grope for and stumble on the truth, and quite another thing with deliberation and method calmly to proceed to its conquest. The latter presupposes a gradually developed terminology containing gradually attained and clarified discriminations. The word Method thus suggests that we should proceed methodically, a thought which is the ultimate outcome of much strenuous experience and reflection. And if instead of humbly and clumsily striving after some dimly apprehended object, we speak of truth and of proof, or of observation, generalisation, definition, and so forth, and arrange them in a rigorously synthetic order, as in Conclusions 14 to 35, we are aware of having stripped off our animality and having become men who can see, and know that they can see, almost infinitely beyond the animal's horizon. In this sense the word Cause embodies a profound methodological discrimination. Deprived of this word and its meaning, we should be tempted to analyse objects or follow processes without noting that we had ignored a category capable of enormously simplifying and rationalising our mental labours. We might be satisfied with determining the accidental relations of uniformities, and thus miss an insight into their crucially important permanent and necessary connections. If, therefore, we deprecate over-emphasis of the causal viewpoint, it is only because it is also methodologically imperious to mete out justice to the various other methodological discriminations arrived at by mankind. In methodology, as in all other spheres of life, we should beware against being biassed in favour of some fractional part of a whole.

We conclude, therefore, that *an ordinary causal enquiry is an enquiry into the more important unconditional and invariable antecedents of certain phenomena.*

SECTION XII.—HYPOTHESES.

§ 35. Consistently with the different views Bacon and Mill adopt concerning the method to be employed in investigating data, they disagree in the value to be assigned to hypotheses, for whereas the former denounced hypotheses not based on an extensive and diversified examination of facts, the latter considered spontaneously arisen hypotheses the main instrument of scientific advance. Jevons and most later logicians agree with Mill, though it is strange that no determined effort should have been made by these logicians to ascertain exactly and in detail the process of arriving at a hypothesis. We know how vigorously Newton denounced recourse to conjectures not suggested by a responsible study of facts, and yet, by a perverse fate, the idlest of idle legends is eternally reiterated to the effect that Newton derived his conception of the law of gravitation from perceiving an apple fall while a youth. Hypotheses are not only figured to-day by many logicians as the *sine qua non* of science: they are looked upon as offering almost the sole device for extending truth. In vain have scholars like Herschel protested that "the liberty of speculation which we possess in the domains of theory is not like the wild licence of the slave broke loose from his fetters, but rather like that of the freeman who has learned the lessons of self-restraint in the school of just subordination". (*Discourse*, [201.]) The protests have roused no echo, and the solid observational activities of the man of science have been placidly ignored.

What is a hypothesis?¹ *We may define it as a plausible conjecture suggested by a careful preliminary examination, for which*

¹ "An hypothesis is any supposition which we make (either without actual evidence, or on evidence avowedly insufficient) in order to endeavour to deduce from it conclusions in accordance with facts which are known to be real; under the idea that if the conclusions to which the hypothesis leads are known truths, the hypothesis itself either must be, or at least is likely to be, true." (Mill, *Logic*, bk. 3, ch. 14, § 4.)

"Hypothesen im wissenschaftlichen Sinne sind weder Tatsachen noch willkürliche und unbegründete Annahmen, sondern Voraussetzungen, die um der Tatsachen willen gemacht werden, aber selbst der tatsächlichen Nachweisung sich entziehen." (Wundt, *Logik*, vol. 1, p. 439.)

"Die Hypothese ist die vorläufige Annahme der Wahrheit einer ungewissen Prämisse, die auf eine dafür gehaltene Ursache geht, zum Zweck ihrer Prüfung an ihren Consequenzen." (Überweg, *System der Logik*, p. 394.) "Wissenschaftliche Hypothesen sind nicht (wie Apelt, *Theorie der Induct.*, sich ausdrückt) 'aus der Luft gegriffene Behauptungen', sondern als Resultate zulässiger Rückschlüsse aus Erfahrungen und zugleich als Prämissen versuchsweiser Deductionen die notwendigen Vorstufen der adäquaten Erkenntniss." (*Ibid.*, p. 386.)

"It [hypothesis] means the suppositions, suggestions, or guesses, as to any matter unknown, leading to experimental or other operations, for proof or disproof." (Bain, *Logic*, vol. 2, p. 128.) "Many hypotheses are of the nature of analogies or comparisons." (*Ibid.*, p. 147.)

the completest proof obtainable is being sought in order to convert it into a fact or established theory. Should an assertion be self-evident, as Euclid's eighth axiom that things which are equal to the same thing are equal to one another, we conceive it as independent of, and as requiring no, proof. On the other hand, if an assertion is patently incredible, as that air is impenetrable by human beings, we dismiss it without striving to prove or disprove it. Nor can we speak of a hypothesis which is incapable of direct and indirect proof, for, by the definition, partial proof alone entitles a conjecture to be raised to the dignity of a hypothesis. A hypothesis, then, asserts something which is neither self-evidently true nor self-evidently false, nor incapable of some kind of proof, as when it is, wrongly, asserted that the cortical substance of the rice

"Hypothesis is a name that may be applied to any conception by which the mind establishes relations between data of testimony, of perception, or of sense, so long as that conception is one among alternative possibilities, and is not referred to reality as a fact." (Bosanquet, *Logic*, vol. 2, p. 155.) "A hypothesis is a hypothesis because it is not, to begin with, present in the data, and has to be brought there by mediation." (*Ibid.*, pp. 169-170.)

"The strength of a hypothesis lies in its power of co-ordinating observed facts and of forecasting intelligently the discoveries of the future." (Whetham, *The Recent Development of Physical Science*, p. 230.)

"Different suggestions present themselves with varying degrees of plausibility. Some are passed by as soon as they arise. Others gain a temporary recognition. Some are explicitly tested with resulting acceptance or rejection. The acceptance of any one explanation involves the rejection of some other explanation. During the process of verification or test the newly advanced supposition is recognised to be more or less doubtful. Besides the hypothesis which is tentatively applied there is recognised the possibility of others." (M. L. Ashley, "The Nature of Hypothesis", in J. Dewey's *Studies in Logical Theory*, 1903, p. 155.) "The predicate arises in case of failure of some line of activity going on in terms of an established habit." (*Ibid.*, p. 170.) "It is pointed out by Welton that the various ways in which hypotheses are suggested may be reduced to three classes, *viz.*, enumerative induction, conversion of propositions, and analogy." (*Ibid.*, p. 171.)

"Aucune règle, aucun principe ne peut guider le savant dans l'art de construire des hypothèses ayant une valeur heuristique: qu'elles ne contredisent à aucune loi précédemment établie, qu'elles soient abandonnées sans retard dès qu'elles reçoivent le moindre démenti de l'expérience, c'est tout ce que l'on peut exiger d'elles. Et, encore, que d'hypothèses contraires à certaines lois qu'on croyait certaines, en contradiction avec certains faits qu'on croyait expliqués, ont cependant triomphé, démontrant la fausseté de ces prétendues lois auxquelles elles contredisaient, la fausse explication des faits qu'on leur opposait. En somme, donc, l'hypothèse est affaire d'intuition; c'est le secret du savant, de l'homme de génie." (Paul Cautlet, *Eléments de sociologie*, 1913, p. 67.)

"Before we go further, however, we must be clear as to one general truth. We must understand that the invention of hypotheses is the work of the scientific genius." (S. H. Mellone, *An Introductory Text-Book of Logic*, 1895, p. 332.) This appears to be also the view of Louis Couturat, in his *Les principes des mathématiques*, 1905.

"The value of an hypothesis depends upon its usefulness and expediency, and on its power of indicating the lines of future inquiry." (E. Thorpe, *History of Chemistry*, vol. 2, p. 95.)

removed in milling counteracts the effects of an excessive starch diet. A plausible assertion is not identical with a hypothesis, because in ordinary life such an assertion is not regarded as demanding proof: it is either conceived as being probable without any reference to proof, or, what is more frequent, the plausibility is at once mentally converted into a certainty. For primitive thinkers proof is something subjective; that is, if a statement forcibly appeals to the feelings, it is forthwith judged to be true. The strongholds of ignorance and error are paved with plausible assertions and sprinkled with stray facts. Hence it would be advisable that terms, such as supposition, conjecture, surmise, suggestion, guess, assumption, should not be considered as co-extensive in methodological signification with the scientifically well-established term Hypothesis which implies that we are searching for proof of an assertion grounded primarily on scientific observation or deduction. To this needs to be added that hypotheses are near neighbours to appropriate fictions or working hypotheses.¹

How is a hypothesis formed? Mill speaks of the "manner in which a conception is selected suitable to express the facts", and affirms "that the process is tentative; that it consists of a succession of guesses; many being rejected, until one at last occurs fit to be chosen". Significantly enough, "the guesses which serve to give mental unity and wholeness to a chaos of scattered particulars are accidents [?] which rarely occur to any minds but those abounding in knowledge and disciplined in intellectual combinations". (*Logic*, bk. 3, ch. 2, § 4.) "An hypothesis", Mill declares, "being a mere supposition, there are no other limits to hypotheses than those of the human imagination." (*Ibid.*, bk. 3, ch. 14, § 4.) And further on: "The process of tracing regularity in any complicated, and at first sight confused, set of appearances, is necessarily tentative: we begin by making any supposition, even a false one, to see what consequences will follow from it; and by observing how these differ from the real phenomena, we learn what corrections to make in our assumption." (*Ibid.*, bk. 3, ch. 14, § 5.) Finally, in what seems his most explicit passage on the subject, Mill states: "Let any one watch the manner in which he himself unravels a complicated mass of evidence; let him observe how, for instance, he

¹ Working hypotheses are frequently "leading" hypotheses, and in their case proof or disproof may occupy centuries, the largest working hypotheses having the longest life as a rule owing to the difficulty of proving much where relatively little is known. Such hypotheses are often admitted to be seriously defective, but they are retained until more satisfactory ones are forthcoming, *e.g.*, Newton's corpuscular theory of light was displaced by Young's undulatory theory of light, because the latter agreed better with the known facts. (A combination of the two theories is now being tested.) In ordinary hypotheses, of course, complete, or very nearly complete, proof, is attainable, *e.g.*, whether the shadow I observe is caused by a cloud or a certain near object.

elicits the true history of any occurrence from the involved statements of one or of many witnesses: he will find that he does not take all the items of evidence into his mind at once, and attempt to weave them together: he extemporises, from a few of the particulars, a first rude theory of the mode in which the facts took place, and then looks at the other statements one by one, to try whether they can be reconciled with that provisional theory, or what alterations or additions it requires to make it square with them." (*Ibid.*) In not one of these instances, it will be perceived, is there a statement concerning the precise whence of a hypothesis, *i.e.*, as to how "the first rude theory" was arrived at.¹

If a hypothesis were a "mere supposition", "any supposition, even a false one", it is impossible to calculate the number of guesses we should be compelled to venture upon before stumbling on the appropriate explanation. Kepler's twenty hypotheses to account for the apparent movements of the planet Mars (which he minutely studied) would become 20,000 or even 20,000,000 hypotheses, and nothing would be more difficult to reach in any instance than the truth.² Yet Mill's pregnant hint that happy guesses "are accidents which rarely occur to any minds but those abounding in knowledge and disciplined in intellectual combinations", strongly suggests that scientific training and conscientious and wide examination of data should precede the formulation of a hypothesis.

§ 36. Moreover, many minds often concentrate on the preparation of one hypothesis. A glance at the history of astronomy from Copernicus to Kant, or at the evolution hypothesis from Lamarck and Darwin to our day, will make this manifest; and

¹ We recognise, with Lotze, that in the process of generalisation something implicit is made explicit. "In most cases what leads us to make the deduction is that a number of individual perceptions $s_1 M$, $s_2 M$, $s_3 M$, thrust themselves one after another on our notice, so waking in us the suspicion that the ground of M is universally to be found in the nature of s , in various examples of which we observe it." (*Logic*, vol. 2, p. 32.) On the other hand, Miss Naden echoes Mill's condemnation of Bacon: "That hasty flight of the mind from particulars to the highest generalisations, which he regards as fundamentally unscientific, is the necessary preliminary of investigation." (*Induction and Deduction*, p. 44.) And yet she admits that "a hypothesis never comes into being without some preliminary induction; rude indeed and imperfect, but as a rule clearly traceable". (*Ibid.*, p. 69.)

² "If Kepler had not known the geometry of conic sections, and had not had in his mind the attributes of the ellipse as proceeding from purely geometrical considerations, to serve as major premises for his calculations, he would never have discovered his first law." (Sigwart, *Logic*, vol. 2, p. 275.) And it might be added that if he had not had many facts at his disposal, it would have been a pure miracle for him to have guessed that the squares of the periodic times of the several planets are proportionate to the cubes of their mean distance from the sun. We may also remark in this connection that he made a life study of the motions of the planets, and that he utilised the imposing collection of facts bequeathed him by Tycho Brahe.

when we reflect that Dr. Joule had been preceded by Davy and Rumford (who had already dimly apprehended the far-reaching theory of the conservation of energy), and was followed by Grove, Maier, Helmholtz, Clerk-Maxwell, and others, who more and more fully developed the theory of the conservation of energy, we shall not be surprised that there are few exceptions, if any, to the rule to which we have here called attention.¹ Mendelyeff admirably illustrates this law of co-operation in the establishment of a comprehensive hypothesis or theory: "I consider it well to observe that no law of nature, however general, has been established all at once; its recognition is always preceded by many presentiments; the establishment of a law, however, does not take place when the first thought of it takes form, or even when its significance is recognised, but only when it has been confirmed by the results of experiment, which the man of science must consider as the only proof of the correctness of his conjectures and opinions. I, therefore, look upon Roscoe . . . and others who verified the adaptability of the periodic law to chemical facts as the true founders of the periodic law, the further development of which still awaits many fresh workers." (*The Principles of Chemistry*, 1905, pp. 18-19.)² Whetham, referring to the interdependence in physical enquiries as illustrated by recent theories relating to chemistry, magnetism, electricity, Röntgen rays, and radio-activity, remarks in the same vein: "The slow and patient work of many observers through long years often leads up to and suggests the particular step from which follows, almost of necessity, the practical application or the far-reaching theory." (*The Recent Development of Physical Science*, p. 198.) And the same author alludes in these terms to the slow historic development of instruments, which are but objective hypotheses: "The spectroscope itself illustrates the progressive triumph of modern science, for it is the work neither of one man nor of one century. Its principles have been developed gradually, and its construction elaborated throughout a couple of hundred years." (*Ibid.*, p. 297.) That epoch-making ideas issue spontaneously from the minds of great

¹ Not only is one hypothesis frequently the product of many minds, but in most instances the hypothesis undergoes a prolonged evolution in its author's mind before it is communicated to the world.

Numerous examples might be cited of the social origin of ideas. The following is selected at haphazard, and others will be found scattered throughout this volume: "Galton and Jäger, Brooks and Nussbaum, Hertwig and Herdman, Nägeli and Weismann, and others, have all contributed to making the fact of continuity more precise. Hopeful also are the suggestions of Jäger, Berthold, Gautier, and Geddes, which make towards a chemical expression of the continuity between germ and germ." (*Chambers' Encyclopædia*, article "Heredity".)

² Mendelyeff was preceded by Newbolt in 1864, and Lothar Meyer made the same discovery as Mendelyeff in the same year, in 1869. See on the periodic law, Charles L. Bloxam, *Chemistry Inorganic and Organic*, 1913, and also the works of Thorpe, Soddy, and Crowther cited.

men is therefore as mythical a belief as that animals came suddenly into being.¹

In pure theory no reason exists why some thinker should not have guessed a world formula which should irresistibly reveal to us the whole mechanism and organism of nature; but in practice, we have seen, the larger generalisations of any value have grown out of smaller ones, and where relevant knowledge did not abound, the hypotheses framed, even if true, could not be verified. If the youthful Newton had observed an apple fall from a tree, and had straightway committed to paper his system of the worlds, Mill's view might be upheld; but the perusal of Newton's *Principia*, with its profuse allusions to other authors, should convince anyone that the apple theory is without justification. When, then, we study the actual facts concerning Newton's theory, say in Sir David Brewster's *Life of Newton*, we are not surprised to learn that many scholars were responsible for the different portions of the solution and that the solution slowly grew, and continued growing after Newton, as the result of mountains of collective labour. We should even experience some difficulty in deciding what vital portion of the general gravitation hypothesis was ascribable to Newton himself, considering that the conception of the unity of the solar system, the revolution of the earth round its axis and round the sun, the discovery of the concept of gravity and its extension to the solar system, the quantitative determination of the velocities and the accelerations of falling bodies, and even the law of inverse squares, were not apparently discovered by the author of the *Principia*.²

Darwin freely adopted suggestions from others:—

"The starting points of many of Darwin's researches were furnished him by other intelligent men." (Frank Cramer, *op. cit.*, p. 47.) "After his return from the Beagle voyage, Mr. Wedgwood of Maer Hall suggested to him that the apparent sinking of superficial bodies, ashes, marl, cinders, etc., in the earth is due to the action of earthworms." (*Ibid.*, p. 48.) "Boitard and Corbié merely made the observation that, when they crossed certain breeds of pigeons, birds coloured like the *Columba livia*, or common dove-

¹ Ernest Naville in his *La logique de l'hypothèse*, recognises that hypotheses should not be accepted till after verification; but, starting with the assumption that hypotheses are the product of genius, he is content to urge his view passionately without examining the evidence.

Welton seems to waver between opposed explanations of hypotheses: "Facility in framing hypotheses cannot be reduced to rule, and hence falls outside the province of logic." (*Manual of Logic*, vol. 2, p. 86.) "In most cases the attempts of previous enquirers have shown more or less plainly in what direction explanation must be sought: either by the partial establishment of some hypothesis, or by making manifest the inadmissibility of others." (*Ibid.*, vol. 2, p. 86.)

² On the same principles Jenner proves to be an enthusiastic summariser and not a discoverer, and this is partly or wholly true of perhaps most men of highest repute. Strange as it may seem, the "great" scientist or artist only appears when the work of invention or discovery has been virtually completed.

cot, were almost invariably produced. It drew Darwin's attention and led to numerous experiments on reversion due to crossing." (*Ibid.*, p. 50.) "Mr. W. Marshall knew that in the mountains of Cumberland many insects adhered to the leaves of *Pinguicula*; he told Darwin, and Darwin told the world. Mr. Holland's statement that water insects are often found imprisoned in the bladders of *Utricularia*, is interesting, chiefly because it led Darwin to investigate the genus." (*Ibid.*, p. 51.) "When Lawson, the Vice-Governor [of the Galapagos Islands] had declared to him that the tortoises from the different islands differed from one another, Darwin did not see the significance of the fact." (*Ibid.*, p. 90.)

If we look narrowly into the matter we learn that all statements are assumptions. Even in answering such questions as Who did it? Why was it done? The answer "Foch", or "Because he wished to outwit the Germans", are assumptions. Such assumptions may be infinitely near the truth, as in the assertions about the law of gravitation, or about what is taking place "under our eyes", or they may be infinitely removed from it, as in gratuitous conjectures. Assumptions may, therefore, be regarded as fundamentally co-extensive with active thought.

§ 37. We shall now study the origin of hypotheses. On a visit to a literary friend I observe that he picks up a capacious envelope, and I ask myself what he proposes to do therewith. I reply, after reflecting a moment: He probably desires to stow away a manuscript. How did I arrive at this hypothesis? I endeavour to form an explanation, and I remember that on my last visit I saw him place a manuscript in such an envelope. This, then, provoked the reply. I cleared up one situation by collating it with a kindred one.

The psychological aspect of the conclusion I reached is far from self-explanatory. To begin with, sundry mental habits need to be allowed for. There is the habit of interesting ourselves in what occurs around us, and the habit of desiring to understand and interpret occurrences. There is the habit of seeking to recall analogous circumstances, and of connecting the new with the old in a more or less bold and methodical manner. Granted, then, that we seek to determine the purpose which the envelope is to serve, the answer must eventually come, if it does come, through partial or total identification, however indirectly, of the present action with a past action. I might have recalled some one else utilising envelopes, or a similar receptacle, for such an object or a related one, or even have reasoned that he would utilise it thus, because I could not think of any other object it could serve. In the latter case I might have glanced round the room, and found that only the manuscript appeared to fit the envelope; but if I had never reasoned from the past to the present, and from the present to the future, and if I had never appreciated the uses to which different objects may be put, no conclusion would have been sought or reached. Again, if I had remembered my literary friend performing this action repeatedly, and many other authors

also proceeding in that way, my conclusion would have been visibly strengthened, and would have presented itself with virtual spontaneity.

We have intentionally selected an incident where one fact was observed; but where many facts have fallen under our observation, or where one fact may be construed in diverse ways, or only with difficulty, the process remains identical. Only, we apply numerous methods in approaching the problem, and fail more than once before we succeed to our complete satisfaction. For this reason the expert, the person who has at his beck and call many methods and facts, triumphs with facility over the inexperienced. That which leaves the layman wholly at sea, is therefore often easily disposed of by the painter, the lawyer, the doctor, the engineer, the navigator, or whoever be the well-informed individual. Direct experience, followed on and accompanied by study, is thus one of the most copious sources of suggestive hypotheses.¹

Only a few further instances of the elaboration of hypotheses may be mentioned in passing. My opinion is asked concerning a book which I have just concluded reading, and I express it. Here, supposing that the book is brilliant, brilliant passages recurred and were noted, and, recalling the contents of the book, the most patent facts in connection therewith are recollected, in accordance with the elementary facts of the purposeful associating of feelings and ideas. The items which recur oftenest, or appeal to me most, obtrude themselves, and are therefore readily remembered. So it is with scientific problems generally.² After having attempted a somewhat exhaustive study of the subject of habit, I desire to know its essential nature, and the element apparently recurring most frequently, that is, the economisation of activity or the suppression in a particular process of thought or action of steps which have been rendered superfluous, suggests itself almost immediately, whilst other less important features tend also to be recalled. Should the hypothesis, on examination, prove inadequate, I re-examine my memory and, if necessary, re-examine the facts. Or, on ascertaining that many negroes have graduated at universities, I tentatively frame the hypothesis

¹ "The relation of the living animals to the fossil species in South America, the manner in which closely allied animals replaced one another as he proceeded southward over the Continent, the South American character of the productions of the Galapagos archipelago, and especially the slight but distinct differences of the flora and fauna on neighbouring islands of the archipelago, impressed [Darwin] so strongly with the peculiar character of the facts and the necessity of a definite mode of origin that he began to see the difference in the logical character of the doctrines of creation and descent." (Frank Cramer, *op. cit.*, p. 214.)

² In these cases, perhaps in all cases, the more systematic and synthetic the process of investigation, the more likely shall we arrive at "the truth, the whole truth, and nothing but the truth".

that average members of perhaps all races of men are able to graduate at universities. Here the *habit* of tentatively generalising important statements (§ 172) is mainly responsible for the hypothesis. Or, striving to think of improvements, I follow as regards a particular object, the rule of recollecting acknowledged defects and clamoured-for perfections, and conceive them as objects to be realised according to admitted principles. (See § 171.) Or, finally, we may develop our special illustration of the mode of forming a hypothesis by extending our generalisation thus: my friend sometimes, frequently, generally, always, keeps manuscripts in envelopes; he stores every kind of manuscript, engraving, extracts from newspapers, classes of letters, etc., in envelopes; he makes parcels of everything. This last case implies that we often seek only for a bare explanation of a single fact, and that it is indifferent circumstances which frequently decide in our unmethodological age how extensive or how reasoned a hypothesis will be.

Of course, certain distinctions should be presupposed. Where much of a scientific character is known, as in certain portions of physics, a cursory scrutiny of facts may suffice for forming a legitimate and sweeping hypothesis. In such an instance, however, we rely on the observations of previous investigators. For this specific reason, *i.e.*, the different developmental stages of a science, years of indefatigable observation may issue in no valid hypothesis, whilst in another department immediate observation may play an inconspicuous part and yet an imposing and true hypothesis readily emerges.¹ Naturally, too, some individuals are better trained than others to appreciate connections of objects and energies, or are more fitted by circumstances for investigating one science than another.

Mill claims that the deductive process consists of an induction, followed by ratiocination and completed by verification. He, however, recognises also a hypothetical method. "The hypothetical method suppresses the first of the three steps, the induction to ascertain the law, and contents itself with the other two operations, ratiocination and verification, the law which is reasoned from being assumed instead of proved." (*Logic*, bk. 3, ch. 14, § 4.) This method, Mill considers, is specially applicable to social problems, and he judges that not until it is adopted, shall we chronicle any noteworthy progress in social science. This exemplifies Mill's extraordinary belief that by a species of spontaneous generation the most far-reaching hypotheses can

¹ The opposite contention, that hypotheses are necessary to observation, is, of course, also true, since alertness involves readiness to be guided by the merest hint. According to his son, Darwin "often said that no one could be a good observer unless he was an active theoriser" (*Charles Darwin*, p. 95); but this only refers to the lowliest grade of hypotheses, and to such as are of methodological importance, as, for instance, the suggestions contained in the Table of Categories.

be formed. Unfortunately many scholars to-day proceed even further on the downward slope and suppress both the first and the third step, supplying us with a fantastic pell-mell of crude conjectures. It is as if a nation desirous of augmenting its wealth, concentrated its energies on opening for this purpose an endless number of lotteries which offer countless prizes of fabulous value, and deprecated all other activities for the creation of wealth.

We may now direct our attention to the subject of generalising which is but another term for hypothetical extension or eduction of statements.

SECTION XIII.—GENERALISATION OR EXTENSION.

§ 38. The ideal end of science, on the theoretical side, is to obtain a world formula, or a correlated or integrated series of formulæ, which shall embrace and suggest all possible general statements.¹ For example, we might arrive at a mechanical or electrical theory of the Universe explaining the physical and chemical properties of matter in terms of electrons and their motions. As Bacon, Schopenhauer, Avenarius, Mach, and a host of other thinkers have pointed out, the immediate and practical object of generalising is an economic one.² The narrowness of the field of consciousness, the slowness marking the communication of ideas, and the quick fading and deterioration of memories, lead to the desire to epitomise our knowledge.

¹ "The ideal of knowledge, no doubt, is . . . in the progressive reduction of reality to a single system or to comprehensive single systems." (Bosanquet, *Logic*, vol. 2, p. 174.) "Every great advance in science consists in a great generalisation, pointing out deep and subtle resemblances." (Jevons, *Principles of Science*, p. 625.) "Legitimate generalisation is the end and aim of all philosophy." (Mill, *Logic*.)

² "It is the duty and virtue of all knowledge to abridge the infinity of individual experience." (Bacon, *Advancement of Learning*, bk. 2.)

"To diminish, as far as possible, the number of general laws necessary for the positive explanation of natural phenomena . . . is the real philosophic purpose of all science." (Comte, *The Fundamental Principles of the Positive Philosophy*, ed. 1905, p. 41.)

"The amount of our knowledge depends upon our power of bringing it within practicable compass. Unless we arrange and classify facts and condense them into general truths, they soon surpass our powers of memory and serve but to confuse." (Jevons, *Principles of Science*, pp. 148-149.)

For an able statement, see Section 4 of Ch. 4, entitled "The Economy of Science," in Ernst Mach, *The Science of Mechanics*, 1902.

"Science has been termed an economy of thought, a shorthand of knowledge, a simplified view of things, a compressed formulation of facts, a brief statement of what is observable, and the like. If this very plausible standpoint be correct, we have in it a striking illustration of the principle of economisation. According to our reading of the facts the following happens in the evolution of truths. Surrounded by innumerable interesting things of most varying aspects, we try hard to comprehend them. Since little time is at our disposal, we make desperate attempts to reach the simplest

*A generalisation, until proved, is an hypothesis which asserts that what holds true of one fact holds true beyond that one fact.*¹ For ordinary purposes the generalising process may be supposed to succeed necessarily the preliminary process of observation, since unclassified facts are scientifically of minimal value.

In defence of the syllogism it has been urged that in all reasoning we assume some general fact, and that an individual fact only exists as a member of a class. In conformity with this it has been argued that the universal and not the particular is real, and that the class precedes the particulars it comprehends. Let us, then, examine what signification is to be attached to the term "General".²

In the special example cited to illustrate the origin of hypotheses we only pre-supposed reasoning from one particular to one other. I reflected: On my former visit my literary friend stowed away a manuscript in a capacious envelope, therefore his picking up a capacious envelope on my present visit is, on general grounds of experience, to be interpreted similarly. Particulars agreeing, likeness was posited. In my mind there need not have been lurking any generalisation to the effect that whenever any one seizes an unusually large envelope, he wishes to stow away a manuscript; or, what was true of the

possible formulation of the world of facts, and in these attempts lie defined the object, motive and method of science. Apart from the process of economisation, therefore, science, with all its implications, has no meaning; and, for the same reason, every truth, every statement, and every generalisation, owes its existence solely to the process of economisation." (G. Spiller, *Mind of Man*, 1902, p. 121.) This implies that science does not deal as a rule with any whole, for such a whole is generally an intricate complex and is, besides, related to the totality of things, rendering it impossible in our day to make concerning it any intelligible statement. However, since the very meaning of a whole is also a mental product, it is unjustifiable to speak of science as not treating of reality because of the present limitations of its scope. Moreover, since the sciences differ in the inclusion of constituent parts as much as pure mathematics does from physiography, it is unprofitable to set up artificial divisions between the subject-matter of science and that of common thought. The latter, indeed, is frequently more abstract than a train of scientific cogitations.

¹ Generalisation is "the act of comprehending under a common name several objects agreeing in some point which we abstract from each of them, and which that common name serves to indicate". (Whately, *Logic*, p. 344.)

"The extension of the concurrence from the observed to the unobserved cases" is alone generalising. (Bain, *Logic*, vol. 2, p. 2.)

"Generalisation consists in passing from observed phenomena to their essential and invariable conditions; in the detection, as Jevons puts it, of a true 'common nature'." (Welton, *Manual of Logic*, p. 193.)

² Sigwart says: "The number of instances from which a universal proposition is obtained makes no fundamental difference in the logical process involved, and the character of the process is obscured when the colligation of a number of similar instances is put forward as its essential feature." (*Logic*, vol. 2, p. 310.) Bosanquet (*Logic*, vol. 2, pp. 177-179) argues along the same line. A sharp distinction needs to be drawn here between formal logic and practical methodology.

given instance, will always hold true of similar instances in the future. An examination of the nature of the General will demonstrate the untenability of such a position, and it will also indicate that often mere intensity or repetition of an experience, rather than reasoning, accounts for a conclusion.

Let us consider an experience. An acquaintance is ascribing to me to-day mistaken, though flattering, motives concerning a certain action of mine. This had also happened yesterday, without my then launching any generalisation. To-day I say to him that both yesterday and to-day the ascription to me of the particular motives was presumably due to his assuming on those occasions that he himself would have been prompted by such motives in those circumstances. Here I reasoned from one particular to a second particular. I now begin systematically to extend. My acquaintance, I think, (1) sometimes, (2) frequently, (3) generally, (4) practically always, (5) invariably, attributes to me certain motives, because he would, in such a situation, be himself actuated by such motives. I further extend this to (6) some, (7) many, (8) very many, (9) most, (10) all people. I continue to extend this to (11) some, (12) many, (13) very many, (14) most, (15) all ideas and sentiments which men possess. I venture on the broad generalisation that (16) people presume others to be and do what they are and do themselves. And, finally, I vaguely surmise that (17) in the Universe like assumes like.

§ 39. The ambiguity involved in the conception of the generalising process would be removed if we were to employ the term Extension instead of the term Generalisation, for extension naturally suggests an indefinite number of stages, whereas generalisation tends to direct attention to one stage only. For instance, scrutinising the nature of the sensations, I assume that special and general memory (vide § 19) would be required in viewing the intruding tide (which I am now watching) a second, third, fourth, or n th time; I then reason to similar objects seen, to sight generally, to sound, and to all the senses. Thus, again, formulating a charter of liberty which refers to individuals, I extend the charter methodically to political and other groups, to humanity as a whole, to the inner life, as well as to art, to all other human activities, and, conditionally, to the whole animal creation. Or noticing that 3^2-1 is divisible by 2, 4^2-1 by 3, and so on, I generalise the formula to n^2-1 , and further to n^m-1 divisible by $n-1$. (Sigwart, *Logic*, vol. 2, p. 212.) Clearly, the first generalisation in any of these cases did not psychologically compel the last, and historic progress is registered in extending generalisations to undreamt-of realms, and to spheres which had been at first expressly excluded from a generalisation. Prof. Creighton justly remarks: "A conception, or mode of regarding things, which has proved serviceable in one field is almost certain to dominate

a whole age, and to be used as an almost universal principle of explanation. The eighteenth century, for example, was greatly under the influence of mechanical ideas. . . . In these later years of the nineteenth century we are dominated by the idea of evolution. The biological notion of an organism which grows or develops has been applied in every possible field. We speak, for example, of the world as an organism rather than as a machine, of the state and of society as organic. And the same conception has been found useful in explaining the nature of human intelligence." (*Introductory Logic*, p. 259.) The fallacy in the absolutist theory of generalisation lay in assuming that either men were ideal thinking mechanisms which generalised everything to the fullest; or that because we sometimes extend a proposition widely, therefore we always do so. All one is entitled to assert is that when men will be thoroughly trained to think in conformity with securely established scientific principles, they will extend every proposition to the farthest limits desirable and practicable in the circumstances.

Many illustrations of the concrete process of generalisation might be cited. Standing on the famous hill which commands Marseilles, one person will exclaim: "How beautiful to observe the town from such an eminence!" Another will say: "I must observe Rome also from an imposing height." Another still: "I must seek to observe some other towns from a hill or mountain." And yet another: "I will endeavour to see every town and place from a convenient altitude." However, fatigue of ascent, time absorbed in reaching a height, bad weather, poor views, absence of eminences, will contribute materially towards persuading the over-sanguine to restrict the generalisation. Another example. One person much enjoys a circular tram trip in a town which he is visiting, and he in no way generalises. Another one will cautiously generalise that when any town is beautiful, and other circumstances are favourable, he will also enjoy a circular trip. A third person will generalise unconditionally, and, if he is on an extensive tour visiting many towns, he will soon learn the folly of indiscriminately generalising. Or one person notices in a picture gallery, without generalising, that every exhibit has affixed to it the date, the name of the artist, and the subject, whilst another person at once thinks, on perceiving the superscriptions, that every kind of exhibition in the world should be as convenient for the visitor as is this picture gallery. Again, in Rome, the present author noticed that the General Post Office was in a court yard. When he saw that this was also the case in Florence, he merely registered the "coincidence". Only when the experience repeated itself in Bologna, did he vaguely and provisionally generalise about General Post Offices in the larger towns of Italy. When, however, the Venice Post Office was found to be in a court yard, he consciously generalised.

Moreover, the difficulty in generalising not infrequently lies in the fact that generalising is inappropriate in multitudes of cases. It is not always true, for instance, that whenever one man imputes to another man certain motives, he reflects what would be his own motives in such circumstances. On the contrary, and this is for us the determining factor to remember, it is often true that men's reasons for ascribing motives to others vary much, and it is not improbable that my acquaintance had only yesterday and to-day acted in the manner indicated, and that he would not again act thus.¹ Let any one attempt to generalise mechanically: This book is well written, therefore all books are well written; this residence is large, therefore all residences are large; Irene is fifteen years old to-day, therefore everybody is fifteen years old to-day; "from the age of zero to the age of one year the child is able to increase its weight 200%" (S. Minot, *op. cit.*, p. 109), therefore we each increase our weight each year by 200%; the blue rays are most efficient for the heliotropic reactions of certain plants, and the yellowish-green rays for the heliotropic reactions of certain animals, yet these facts cannot be generalised; or, since the fertilised ovum increases a billionfold in size within nine months, therefore we increase a billionfold in size every nine months; and he will appreciate the limitations to mechanical generalising.² From every point of view, then, we infer that there is nothing rounded about a generalisation; that it is not always justifiable to generalise; that there is no dividing line between an extension of one particular to one other or to a comprehensive class; and that it is often expedient to refrain from generalising, to extend only to a second circumstance or to several circumstances, and so on *ad indefinitum*. When to generalise,³ and to what extent to generalise, is in the present day a matter of capricious habit, but will be in futurity a question of science. (See on this point Conclusion 25*i*.)

We thus comprehend why men resort to a universalised form of speech. "In common discourse", Isaac Watts judiciously remarks, "we usually denominate persons and things according to the major part of their character. He is to be called a wise man who has but few follies; he is a good philo-

¹ As Darwin incisively expressed this: "Any fool can generalise and speculate." (Frank Cramer, *op. cit.*, p. 39.)

² Dictionary makers frequently generalise mechanically. Thus one dictionary gives as part of the definition of "Swiss" "the language of Switzerland", and another dictionary, "its language", when, of course, there is no "Swiss language".

³ "Where we observe the same mark in different subjects, we are predisposed to think that the agreement is not a chance one and that the different subjects have not therefore stumbled upon the same predicate each through a special circumstance of its own, but are all radically of one common essence, of which their possession of the same mark is the consequence." (Lotze, *Logic*, vol. 1, p. 134.)

sopher who knows much of nature, and for the most part reasons well in matters of human science; and that book should be esteemed well written, which has more of good sense in it than it has of impertinence." (*Logic*, p. 178.) And in the Preface to La Rochefoucauld's famous *Reflections*, we read: "Common conversation teaches us that even where general expressions are used, we take them in a limited sense, with such and such restrictions. . . . As, for example, when we hear a man say, 'All Paris went to meet the king', or 'All the court was at the play', every one knows that it only signifies the greater part." Similarly there is value in an indefinite generalised statement, as when it is contended that "the overwhelming majority of organisms have a bilaterally symmetrical structure". (J. Loeb, *Forced Movements*, 1918, p. 13.)

§ 40. Besides, as we have seen (§ 7), the Universe is as a totality stable if brief periods are considered, and all but the scientifically trained, misled by this, tend, therefore, to generalise where wiser men prudently discriminate. "Suffering ennobles", "Suffering degrades"; "By answering injury with kindness, we touch others' hearts", "By answering injury with kindness, we invite and create callousness"; "Some persons defy their environment, therefore environment is of no consequence in morals", "Some persons are crushed by their environment, therefore environment is of infinite significance in morals"; "Out of sight, out of mind", "Absence makes the heart grow fonder"; "Religion (health, intellect, sympathy, resoluteness) is everything in morality"; "There is a universal conscience", "The conscience varies with each people and age"; "Self-reliance is everything", "Social devotion is everything"; and a hundred other popular but contradictory generalisations illustrate the fact that men are almost incurably addicted to building broad generalisations on slender experience.¹

Nor is precipitancy by any means confined to the masses. Not a few educationists, for example, are fond of generalising. Having perceived certain advantages accruing from the child being interested in his school work, interest is forthwith conceived as the be-all and end-all of education. Likewise, self-dependence, collaboration, games, concrete study, science teaching, the cultivation of the æsthetic sense, physical culture, manual training, classics, religious lessons, vocational preparation, and diverse other forms of education, are each in succession, and on equally inadequate grounds, proclaimed to possess the power of revolutionising the spiritual nature of the child. So, too, arguing from a caricature of the earlier stages of man's history and from imperfect observation of child life, it has been widely maintained that the child tends to repeat the history of man

¹ "Generalisation is the great prerogative of the intellect, but it is a power only to be exercised safely with much caution and after long training." (Jevons, *Principles of Science*, p. 626.)

in its general outlines, and that his educators should respect this tendency in the child, and even be ruled thereby. This doubly dubious analogy could have been easily ascertained to be spurious by noting that the children of primitive folk pass through the same phases as those of Western people, and that the life of primitive and semi-civilised men is intrinsically that of adults and not of children. Educators, moreover, are prone to surmise—this is the educator's fallacy *par excellence*—that whatever children are taught in a certain place and in a certain connection, they will appropriately generalise to all suitable places and suitable connections, erroneously ascribing a power to the immature which the ideally trained thinker would envy. And, of course, what is so largely true of the teaching profession, is in all probability equally true of most other professions and callings.

Scholars, however, not infrequently indulge in the opposite tendency of fixing limits. Bacon told us that "it is impossible that air should ever be consistent, or put off its fluidity". (*Novum Organum*, bk. 2, 33.) Comte confidently declared that a sidereal chemistry is a chimera, and this on the eve of decisive discoveries in this most fascinating domain of science. Bain argues: "All assertions as to the ultimate structure of the particles of matter are, and ever must be, hypothetical. . . . That heat consists of the motions of the atoms can never be directly shown." (*Logic*, vol. 2, p. 132.) And very common is the assumption that the stage of civilisation reached to-day will not be appreciably excelled in the future, ignoring that since mankind has made inconceivably great advances in the past, it is likely to make inconceivably great advances in the future, advances suggestive of a world as much ahead of our own day as ours is ahead of early paleolithic times. Only a general training in scientific method can save us from the two extremes, and place us in a position to generalise warily whilst rejecting all hypothetical limitations.

We have reasoned throughout this Section as if in the process of generalisation we commenced invariably with observing particular facts, and then generalised our observations. The actual process of thought, however, is often far from being so free from complications. As everybody is aware, an enquiry is seldom wholly novel, and even beyond this lies the fact that we start as adults with a colossal army of more or less confused notions and generalisations at our disposal. From this it is to be inferred that perhaps more frequently than not we are scrutinising a series of facts which, to our knowledge, has been previously examined and generalised by others. Conformably, we find, as a rule, generalisations to hand, and our concern is not seldom to correct, remould, or replace them. Indeed, the steady historic advance in reliable information implies that we are mainly modifying and extending, rather

than creating, generalisations. Moreover, without an accepted principle of classification to guide us, and a copious number of generalisations to mark out for us the limits of our enquiry, the process of generalisation would be probably to all intents meaningless and vain, indeed impossible. (See Section V and Conclusion 33.)

§ 41. We ought to distinguish at least three classes of generalisation. First, *simple generalisation*, where what is asserted of a phenomenon, say a new fact about a certain colour, is extended to a second colour or to its own highest class, the sense of sight. Secondly, *compound generalisation*, where what is asserted of a class, *e.g.*, a novel fact concerning the sense of sight, is extended to more or less closely related classes—to some or all the remaining senses, etc. And, lastly, *universal generalisation*, where we extend to what is remotely related, as reasoning from the nature of the senses to the memory, and thence to the brain and, beyond, to life and matter in general.¹

§ 42. It is also not unconditionally true that science is only concerned with general facts. The chemist frequently reasons from one substance to a second substance or to a small group of substances. The physicist not seldom endeavours to connect one force with one other, as magnetism with electricity, light with heat, and light with electricity (as in Clerk-Maxwell's electromagnetic theory of light), or argues from the existence of a magnetic field to the existence of a gravitational field. And, generally speaking, there are myriads of occasions when a scientific extension does not pass beyond a second or a few facts. Moreover, astronomers will observe a single eclipse or a single star; physicists reduce one gas after another to the liquid and solid state;² chemists add one element to another; seismologists will inquire into the causes of a certain earthquake or volcanic eruption; geologists will describe the strata of a certain region; anthropologists will compose a monograph on a single tribe; and economists will investigate the economic condition of a particular district of a particular country at a particular time. There is, in other words, a cumulative as well as a generalising aspect to scientific enquiries, the former of which is well illus-

¹ Here is a broad generalisation, summing up the general nature of all waves, whether connected with light, heat, sound, etc.:—

"1.—The disturbance takes time to travel from one point to another.

2.—The disturbance is propagated through a medium.

3.—On meeting an obstacle the waves are reflected back, and the angles of incidence and reflection are equal.

4.—The course of the waves is changed, *i.e.*, they are refracted, when they pass from one medium to another in which the rate of travel is different.

5.—The disturbance of a particle of the medium is alternating and not continuous in one direction." (J. H. Poynting and J. J. Thomson, *Sound*, 1913, pp. 3-4.)

² This has now been accomplished as regards all gases.

trated in the gigantic collection of facts pertaining to topography, the charting of the seas, and weather lore.

§ 43. We must touch upon two other aspects. The uniformity of nature is a fundamental assumption of science. When, therefore, we have some pure nitrogen before us in a flask, we are bound to assert that whatever holds good of this sample in the given conditions will necessarily hold good of all pure nitrogen under identical conditions. In instances of this character, as in the problems of mechanics and chemistry, no question of generalising arises, for he who would assume that a particular body in motion would, but for friction and other opposing forces such as gravitation, continue for ever in motion, without implicitly positing that this was true of all bodies, would appear to be necessarily confused in his thought.¹ When, however, we venture on an assertion concerning a complex matter, say a man's conduct, it is patent that unreasoned generalising in regard to that matter and the species to which it belongs—on the mistaken assumption that one member of a class exactly resembles all its companions—is unwarranted. Undoubted truths are, therefore, as yet very limited, and we should think of most of our generalisations as contingent rather than as necessarily true.

This brings us to our second point. As we have just seen, in the case of a chemical element or a primary mechanical property, the existing simplicity renders elaborate generalising superfluous and void of meaning. At the other end of the scale, we discern such diversity that we cannot speak of classes in the ordinary sense of the word. To reason that since Washington, Paris, London, Berlin, and Rome are capitals, therefore their general architectural style is identical, would be to fly in the face of the facts. Still, two landscapes may be much alike, in which case we form the two into a class; or a certain number of species resemble one another markedly, and we form them into a genus. In other words, if we extend deliberately, then all extension is generalisation, and no form of extension should be deemed to fall outside the process of generalising.

§ 44. In science generally the number of facts—*e.g.*, in biology—is so prodigious that simple enumeration is commonly precluded. Nevertheless, in many directions complete or perfect inductions, to use the antiquated expression for generalisations, may be obtained, and there they are in place. The present writer was once, as a visitor, in a school-room, and asked the

¹ Animal bodies, on account of their instability and their possible self-determined motions, raise a doubt as to the legitimacy of the generalisation; and if even the elements should be undergoing incessant change, and electrical and other influences should be all-pervasive, the doubt would be universally extended in respect of this proposition. We assume, however, that any such internal changes or external influences are absent, and that we discount them if they are present.

teacher the ages of the children. The teacher turned to the first boy at the right hand termination of the first row, and inquired of him "How old are you?" Then, so soon as the reply came, rapidly to the second boy seated next to the first one: "And you?" and so on to the last of the twenty-five scholars. A few minutes later the visitor inquired what social position the children's parents occupied, and the process of complete enumeration was repeated. In scientific activities the completest enumeration of classes is habitually resorted to where feasible, as for instance in the subjoined example adverting to Faraday's researches: "He subjected bodies of the most varied qualities to the action of his magnet: mineral salts, acids, alkalis, ethers, alcohols, aqueous solutions, glass, phosphorus, resins, oils, essences, vegetable and animal tissues, and found them all amenable to magnetic influences. No known solid or liquid proved insensible to the magnetic power when developed in sufficient strength. All the tissues of the human body, the blood—though it contains iron—included, were proved to be diamagnetic." (Tyndall, *Faraday as a Discoverer*, p. 91.)¹ Not a few scientists would profit incalculably if they decided on as large a survey of their subject as Bacon undertook when examining the nature of heat, and the day is surely near when methodologists will be agreed in the demand that Bacon's example should be universally imitated where the facts are ascertainable with fair ease. For instance, instead of stating in a serious discussion that the great facts of life are nutrition, growth, and reproduction, we ought to enumerate all the leading factors: irritability, contractility, nutrition, adaptation, regeneration, growth, senescence, death, reproduction, variation, heredity, and evolution.

¹ "All this Newton accomplished by the simple and elegant contrivance of enclosing in a hollow pendulum the same weights of a great number of substances the most different that could be found in all respects, as gold, glass, wood, water, wheat, etc. . . ." (Herschel, *Discourse*, [179.].)

"Ramsay, in conjunction with Travers, spent several years in a hunt for the missing elements. They heated upwards of a hundred minerals. . . . Mineral waters were boiled, so as to expel dissolved gases. . . . Even meteorites . . . were heated." (Sir William Ramsay, *Essays Biographical and Chemical*, 1908, p. 153.) "By the analysis of an almost incredibly large number of compounds, he [Berzelius] established on a firm basis the constancy of the composition of compounds, and the law of multiple proportions." (*Ibid.*, p. 162.) To ascertain the systematic motion of stars, we are told in the *Report of the British Association for the Advancement of Science* for 1908, 1800 stars from all the parts of the sky were examined (p. 604). "In the year 1900, M. and Mme. Curie made a systematic search of these effects in a great number of chemical elements and compounds and in many natural minerals." (Whetham, *The Recent Development of Physical Science*, pp. 200–201.)

"So fand Kepler sein drittes Gesetz, dass die Quadrate der Umlaufzeiten der Planeten sich verhalten wie die Würfel ihrer mittleren Entfernungen von der Sonne, durch eine vollständige Induction, nämlich durch eine Vergleichung der mittleren Abstände aller damals bekannten Planeten von der

It has been objected that complete induction is the equivalent of simple enumeration, but psychologically this does not appear to be so. The value of the complete enumeration, exactly as in incomplete induction, resides in the comprehensive summing up. $1 + 1$ is commonly written 2, or $1 + 1 = 2$; but really $1 + 1$ is not equal to 2, it is not even equal to $1 + 1$; it is $1 + 1$.¹ The 2 holds together the two 1's, and represents a new fact. That is to say, since the one matter of consequence is to arrive at a general statement, it follows that it is immaterial whether we reach it by inference or by enumeration.² Indeed, the word All indicates a process of thought not involved in the enumeration, say, of twenty objects, for, abstractly speaking, twenty objects may be but a portion of "all" objects, whereas by the term All we judge that the class consists of no fewer and no more than twenty objects. "All the books in this library are English books" (Jevons), expresses a qualitatively different statement from "435 books in this library are English books". A study of the mathematical notions of children between the ages of three and five would help to fix these delicate methodological and psychological distinctions.

Sonne mit ihren Umlaufzeiten." (C. S. Cornelius, *Über die Bedeutung des Causalprinzips in der Naturwissenschaft*, Halle, 1867, p. 7.)

"One would naturally suppose that the colours and lines of mother-of-pearl were due to the chemical or physical character of the substance itself. Sir David Brewster, however, happened to take an impression of a piece of mother-of-pearl in beeswax and resin, and was surprised to see the colours reproduced upon its surface. He then took a number of other impressions in balsam, gum-arabic, lead, etc., and found the iridescent colours repeated in every case. In this way he proved that the colours were caused by the form of the substance, and not by its chemical qualities or physical composition." (J. E. Creighton, *An Introduction to Logic*, pp. 202-203.)

"To determine its position [the position of the cirriped] he studied the structure of as many genera as possible. Dr. J. E. Gray, who had already collected a large amount of material for a monograph of the group, turned it over to Darwin." (Frank Cramer, *op. cit.*, pp. 49-50.) In order to ascertain whether the primrose and the cowslip were different forms of the same species, "he transplanted cowslips from the fields into a shrubbery, and then into highly manured land; the next year they were protected from insects, artificially fertilised, and seed grown, which was sown in a hot-bed. The young plants were set out, some in very rich soil, some in stiff, poor clay, some in old peat, and others in pots in the greenhouse—765 in all." (*Ibid.*, pp. 82-83.)

"The presence of the fat-soluble factor . . . has also been found present in many oils and fats derived from the animal kingdom, as for example, cod-liver oil, shark-liver oil, beef fat, the fats of kidneys, heart muscle and liver tissues, herring oil, cod oil, salmon oil, and whale oil." (*Report on . . . Vitamines*, p. 21.)

"Sir Charles Lyell was preparing a third edition of his *Principles*, and, as was his habit, visited every site in Europe where any discovery of note had been made." (A. Keith, *op. cit.*, p. 48.)

¹ On the philosophical aspect of this problem, see Léon Brunschvicg, *Les étapes de la philosophie mathématique*, Paris, 1912, ch. 21.

² "The problem of all inferential processes is naturally this, from given data or premisses to develop as much new truth as possible." (Lotze, *Logic*, vol. 1, pp. 133-134.) It is new truths in which mankind is interested.

In certain departments of knowledge it is hazardous to reason from a few particulars to the general, and in those departments enumerations tend to partake of completeness. For instance, the population of a town or country, at a given date, as well as many other social facts, are determined by complete enumeration. In the same way rain gauges, thermometrical and wind records, graphs, questionnaires, and similar means are employed for the purpose of obtaining a knowledge of general facts which may afterwards form a basis for deductions. So, too, the number of species of discovered animals and plants is counted, and a census is taken of the host of stars. A related method is expressed by the law of averages where series of facts diverging within certain limits are reduced to unity by extracting the average of the series. Complete inductions play also an important part in textual criticism. The various Bibles and Classics of the world—for instance, the sacred books of the East—have been thus subjected to a treatment where almost every detail is exhaustively enumerated, and nothing is taken for granted. In these several cases the end—general statements—is identical with that in incomplete inductions (which, after all, often tend to approach completeness), and both kinds of inductions represent methods utilised in science. Individuals are to be met with in every walk of life who, if a moderate additional effort will secure it, prefer the certain to the uncertain, and frequently perform complete inductions, or the most complete ones practicable, where they might have been satisfied with relatively incomplete ones. Their procedure is to be commended methodologically.¹

§ 45. A generalisation may, therefore, only be legitimately attempted where appreciable time and thought would be saved by its being posited. If, for example, some one desired to understand the fundamental nature of the sensations, he would do well to draw up, before venturing on a comparison between the sensations with a view to learning how far they are distinct, very complete lists of the leading characteristics of the various senses, afterwards treating them synthetically in accordance with Conclusions 14 to 35. In a *preliminary* survey—utilising § 172 more especially, and seeking pertinaciously by observation, experiment, and comparison, for new points until no further points reveal themselves²—he might enumerate the peculiarities

¹ On complete induction, see Bradley's *Logic*, pp. 329–330.

² Here is the vital test of a methodology. Granted fair acquaintance with the subject of Sound as a whole, most of the material should be *directly* derived through the application of methodological rules. *E.g.*, Conclusions 19 and 20 would inform us where to find our material; the second Table of the Primary Categories would direct us to other important aspects; and Conclusions 27 and 28 would further ensure exhausting the subject. Also, since the aim is to compare, comparison will be a fertile source of suggestions. The task should be thus completed in one-tenth of the time and be of ten times greater scientific value. This is presumably what Bacon meant by “helps” for the understanding.

of (say) sound sensations as follows, omitting at first fine distinctions:—

A. SENSE APPARATUS.—1. We connect sound with a special sense apparatus: the two ears and their afferent continuations. 2. However, sounds may, to a marked degree, reach the internal ear directly, as seen in loud breathing with ears closed. 3. We ordinarily hear with both ears. 4. The use of only one ear makes comparatively little difference to the loudness and to the quality of the sounds heard. (Compare with monocular vision.) 5. In normal circumstances we cannot tell whether we hear with both ears, except by indirect methods or by trained attention. 6. The ears are so placed that sounds are readily heard from all sides. 7. The ear, unlike the eye, is never closed, presumably because of the need of alertness to danger. 8. The ears can only be closed artificially, and even then sound, when loud, penetrates as a rule to a certain extent. (See also 2.) 9. As implied in 6, sounds, unlike sights, are not readily localised in a direct line with the sense apparatus, though “right” and “left” have a fairly definite meaning to the ears as a rule (*e.g.*, sharply waving a finger close by the ear—to the right and left, above, below, and immediately opposite, sound is only noticeable in the last instance, and then very distinctly). 10. The direction whence sounds emanate can be only imperfectly ascertained through hearing alone, and exact aural localisation in respect of direction and distance is still more difficult (as is evidenced by dogs who are at a loss to trace their unseen master by his voice). (Movements of the head assist to some extent in tracing sound direction.) 11. Certain parts of the external ear and meatus may possibly be more sensitive to auditory vibrations, and thus help to guide in the interpretation of direction, whilst sounds (*e.g.*, occasioned by strong air currents), definitely coming from right or left, more distinctly affect the correspondingly situated ear. 12. With sounds, unlike with sights, their close proximity to the sense apparatus does not markedly modify them, save in regard to loudness. 13. In intently listening, we cease moving and breathing, because of the disturbing noises created in these processes. 14. Sound is received with almost complete passivity. 15. Sounds are correspondingly aggressive in their higher reaches. 16. The degree of loudness in a sound, like all intensity in sensations, is not appreciated by the sense of hearing, but by the attention mechanism.

B. MEDIUM.—1. Sound is distinctly connected with traceable wave media, commonly with the air; but, as in gently rubbing the temples, a vibration may be directly transmitted to the internal ear. (See A 2 above.) 2. Because of 1, sounds manifest timbre or quality, resulting from the specific form of the vibrations; pitch, determined by the frequency of the vibrations; and intensity, caused by the amplitude of the vibrations. 3. Echoes,

single and multiple, are the result of the reflection of the vibrations by a spacious obstacle at a certain distance, in certain circumstances; and resonance results from conditions where the sounds are strengthened or reinforced. 4. Sounds often tend to continue beyond the action which gave rise to them, because they are due to the vibration of objects (as when we have ceased striking a bell with a hammer). 5. Sound waves, and therefore sounds, travel far more slowly than light waves (1,120 feet against 186,000 miles per second!); hence the flash from a distant gun at night reaches us some time before the connected explosion is heard. 6. Sound waves are quickly exhausted; hence ordinary sounds in an ordinary medium are only heard from a short distance, say up to a quarter of a mile, and no sounds are distinguished beyond (say) 50 miles. 7. The exhaustion of sound waves is gradual; hence sounds fade with distance, detail and diversity gradually passing away. 8. Hence, *per contra*, only those infinitely few sound waves and sounds reach us which emanate from comparatively near objects, excluding some exceptional sounds of great violence. 9. Sound waves, and therefore sounds, are also liable to deflection, and hence a strong wind, according to its direction, favours or opposes sounds reaching us. 10. Non-periodic and periodic sound vibrations are said to account for "noise" and "harmony". 11. Sound waves, and therefore sounds, are only partially affected by most intervening objects, such as windows or walls. 12. Sound waves, and therefore sounds, interfere and fuse with one another (*e.g.*, a band playing). 13. Loud sounds, as in a busy thoroughfare, "drown" low ones, and great stillness, as at night, contributes to the discernment of comparatively very low sounds. 14. Sound waves of no more than about 50 vibrations and over about 20,000 vibrations, are inaudible. 15. The world of sound is sometimes given in a co-existing and successive series (*e.g.*, a concert).

C. OBJECTS.—1. Sounds emanate from objects. 2. Sounds normally represent objects as a whole—in their three dimensions, and not, as with sight, surfaces only. (Note being in a room, and hearing some one on the floor above stamp his feet—the whole thickness of the ceiling is involved.) 3. Sounds deal with objects in motion, molecular and molar, there being usually two objects concerned, the one acting, the other acted upon; but in the case of wind, for instance, the object and the medium are identical. 4. The source of sound in objects is a vibratory motion—sometimes visible, sometimes palpable, also illustrated by 2. 5. Comparative voluminousness of bodies vibrating explains massiveness and fineness of sound. 6. Sounds vary according to the varying composition of objects. 7. In proportion to the energy of a movement or vibration, sound is perceived from a shorter or longer distance. 8. Sounds differ with consistency, size, shape, and other physical qualities of sub-

stances. 9. Sounds possess no extremely definite qualities, such as vision proffers us in red and green, apparently because the constitution of objects varies indefinitely. 10. There exists, for the above reason, no practical limit to the number of different classes of sounds. 11. If an object is prevented from continuing to vibrate, the sound is deadened, and where there is no vibratory medium, as in a complete vacuum, no sound is producible. 12. The world of sound, unlike that of sight, is generally discontinuous, and generally presents a complex object by a virtually single-featured sound; consequently the world of sound is almost infinitely poorer in material presented than the world of sight; this because sound depends on the sensible action and vibration of objects, because such action is as a rule exceedingly rare, and because ordinary sounds are only heard for a short distance. (Compare looking at a dog and listening to his occasional barking, or looking at and listening to a cricket match from a distance of a few hundred yards, but allow for waterfalls, etc.) 13. Sounds, implying as they normally do occasional action on the part of objects, form only a forward time series as a rule, that is, we cannot ordinarily return to a sound as we can to something seen. 14. Involving intermittent action in objects, sounds generally take us by surprise. 15. Diversity, frequency, and intensity of sounds, vary with diversity, frequency, and intensity of vibration in an object. 16. Certain classes of sounds are connected with certain classes of objects (*e.g.*, the sounds emitted by vibrating silver or gold). 17. Knowledge of certain sounds is frequently connected with certain known objects (*e.g.*, a friend's voice).

D. THE VOICE.—1. We possess a special organ for producing sounds, the vocal chords. 2. Sounds form the chief means of direct communication between men (and between most terrestrial animals). 3. Speaking is guided by hearing, and hence when hearing becomes disordered, speech also suffers. 4. Speech for man is both active (speaking) and passive (hearing). 5. Since it is in our power to generate sounds, we can hear sound at will, provided a vibrant medium is present and we are not forced into silence. 6. Experimental knowledge of sounds, resulting from a certain deliberate activity of the vocal chords, etc., should be allowed for. 7. "Silent" reading and reflecting are usually auditive in character.

E. IMAGERY, IMAGINATION, FEELING, INTELLIGENCE.—1. Sound is second in order, sight being first, in respect of the facility with which sensations can be imaged. 2. Subjective sounds are represented by such sounds as singing in the ears and hallucinations. 3. In growing tired or sleepy, and in dreams, sound becomes either inaudible, or is disturbed or distorted through misapprehension of its source. 4. Auditory hallucinations are especially dangerous; because the origin of sounds is usually problematical, sounds frequently breaking in

on us unexpectedly. 5. Sounds have a strong pleasure-pain quality, as music, rasping noise. 6. Loud sounds startle and are painful. 7. Sounds stand first in order in regard to warmth of feeling engendered. 8. Sound stands second in order, sight being first, so far as gaining information is concerned. 9. With the attention otherwise deeply engaged, ordinary sounds are not heard.

F. THE MOST SALIENT FACTS.—1. Auditory apparatus; dependence on the occasional sensible action and vibration of comparatively near objects, on a medium (commonly the atmosphere) easily thrown into vibration by that action and also easily disturbed, and on the vibrations of that medium reaching the ears; ill-defined qualitative distinctions; lowness and loudness, also representing remoteness and proximity, of sounds; massiveness and fineness; together with “noise” and “harmony” (ambiguous terms!),¹ constitute the principal audile facts. 2. Sounds can be imitated by gramophone, telephone, etc. 3. Very faint noises furnish the nearest approach to feelings or touch.²

G. TENTATIVE GENERAL CONCLUSION.—Sound sensations are only classed separately from other sensations because of the secondary circumstances enumerated above.³

Having somewhat fully discussed what is implied in the term generalisation, we may venture on an analysis of the process of verification which properly concludes the process of generalising, but is no less essential to observation and deduction. That generalisations should be graded, comprehensive, important, numerous, full, rational and relevant, original, automatically initiated, and methodically extended, we shall learn from Conclusion 25.

SECTION XIV.—VERIFICATION AND PROOF.

§ 46. (*A*) *Verification may be defined as the critical comparison of an assertion with the data to which it is alleged to correspond.*

All that we have stated of the need of meticulous, minute, and wide examination of facts holds with double force of veri-

¹ For a discussion of these two terms, see Carl Stumpf, *Tonpsychologie*, vol. 2, 1890, § 28.

² So far as classes of facts are concerned, Bacon aimed in his tables at complete enumeration, as may be inferred from his enquiry into the nature of heat and his essays on *The Winds* and on *Life and Death*. The list of visual characteristics prepared by the author contains some three hundred items. Only on the basis of such exhaustive analyses are we likely to determine the fundamental peculiarities of sensations. Three centuries ago Bacon stated that Music had received fair attention, but not Sound. Incredible as it may appear, his dictum appears also to apply to to-day.

³ Leading works on the subject of Sound are: H. Helmholtz, *Die Lehre von den Tonempfindungen*, 1877; John Tyndall, *Sound*, 1893; and Lord Rayleigh, *Theory of Sound*, 1902. An exhaustive work is Richard Klimpert, *Lehrbuch der Akustik*, 4 vols., 1904–1907.

fication. Just as it is unscientific to generalise in an unknown field from one or a few instances, so verification, save in a crucial experiment, is unscientific if it only embraces one or a few occurrences, or if it rests "upon anything but a very extensive comparison with a great mass of observed facts". (Herschel, *Discourse*, [219.].) Verification is peculiarly a process employed in the sciences, a process which is mostly omitted in ordinary life, or else is performed in a perfunctory manner.

Verification may signify in a certain connection re-examination, as when we desire to examine the correctness of a previous observation; or it may mean examination, as when a generalisation is to be tested. Verification may also proceed by calculation, as in the discovery of the planet Uranus; by reasoning, as when the matter to be verified is a geometrical proposition; or by reasoning and feeling, as when beauty and goodness are involved. Rules as to repeated examination, exhaustion of conditions, a critical attitude, especially apply here. (See Conclusions 22 to 24.)

Those who favour the unceremonious framing of hypotheses frequently maintain that no harm will ensue provided we are careful to verify them. In this they assume that verification is not encircled by obstacles, whereas verifying a justifiable hypothesis may be the work of a generation, whilst the attempt to verify unwarranted hypotheses usually connotes an endless task leading often to deeper and deeper misconceptions. The decline of Rome, for instance, has found many hypothetical explanations, any one of which may conceivably be true. It is contended that nations decay like individuals; that the superior types had been eliminated by the wars; that the Barbarians rushed and crushed Rome; that growing immorality and luxurious living robbed Rome of its stamina; and that the introduction of malaria sapped the health of its inhabitants. Here are five hypotheses, and it would be easy to augment their number. The difficulty, almost an insuperable one, manifestly lies in proving one or more of them to be correct. Likewise, the apparent differences in the size of the full moon on the horizon and at the zenith, have led to the formation of sundry hypotheses, none of which have yet been substantiated. Premature indulgence in speculation tends, in fact, to make confusion worse confounded, and supplies the unwary with a trap instead of with a bridge.

There are two grades of verification—simple and deductive, and the references above have only been to the first. In the former case we only examine a number of impartially and judiciously selected specimens to test the truth of a hypothetical proposition. In the latter, we reason that if the proposition *A* holds, the propositions *A*1, *A*2, *A*3 will also hold, and that if we therefore perceive that *A*1, *A*2, *A*3, do hold, *A* probably represents the facts correctly. The supreme anxiety should be

to frame legitimate inferences, and for both types of verification it is of crucial moment that the basal generalisations shall be lucidly expressed.

§ 47. (B) *Proof may be regarded as the process whereby the truth of a statement is established beyond a reasonable doubt.* Bacon's synthetic procedure, which we follow in a modernised form in Part V, is one eminently suitable for proving propositions of a certain general order. By registering all relevant affirmative class instances, then class instances similar but negating the former, then determining the degree of the presence of a quality, then excluding automatically what is not common to all cases, and then framing a general statement in the form of a guarded definition, the greatest practical assurance is obtained that we have a fully proved statement before us. The comprehensive nature of the procedure, and the reliance on fact rather than on sweeping hypotheses, further accentuate its evidential value, especially when supplementary dialectical methods, such as Bacon suggests, or as are suggested in Conclusions 27 and 28, are employed to ensure that nothing escapes from the closely woven meshes.

John Stuart Mill, following Bacon and Herschel, proposed, as we have seen, five decisive methods of testing statements dealing with causes: the Canons of Agreement, Difference, Joint Method of Difference and Agreement, Residue, and Concomitant Variation. (For details, see § 17.) These should be all applied when practicable. However, two factors need to be taken into account in respect of them. First, that the progressive nature of truth most rarely admits of the rigorous application of these Canons, and, secondly, that, as a matter of fact, most present-day scientific enquiries are in too undeveloped a condition to permit the Canons being frequently utilised, except tentatively. And what holds of causal, holds equally of static, facts.

Canons of probability are, therefore, needed, both in regard to static and dynamic phenomena, to supplement Mill's Canons. The principal ones applied to a hypothesis are general agreement with existing knowledge, withstanding deductive tests, leading to new truths, and not being invalidated by fresh information. However, many hypotheses are working hypotheses, and admittedly do not harmonise with all the recognised facts. Furthermore, the special sciences apply, in addition, auxiliary tests. In chemistry, reagents; in geology and in the historical sciences, analogy; in botany, the test of fitting into the botanical scheme of classification; in physiology, staining; and in other sciences, other acknowledged tests, are resorted to. Simple verification, instrumental or otherwise, is a further criterion. To be sure, every science acts as such as a check upon alleged additions to knowledge, and almost invariably it possesses special methods for testing its particular class of truths. In art and in conduct

the principal appeal would be probably to the achievements of the great masters (as representing the flood level of great epochs) and to educated thought and feeling.

As the interdependence of facts obtrudes itself more and more on the consciousness of men of science, they are less and less inclined to seek for laws of nature or, what is their equivalent, general facts to which no exception can be discovered.¹ At the same time it is the earnest concern of science to arrive at irreproachable statements, for only these can be entirely relied on or fully utilised for deductive purposes. Such statements should not be, however, platitudinarian, for to state that gold is always yellow, the wind-lashed sea invariably vocal, or that "air has weight",² would be puerile. Given, then, a comprehensive and pregnant law established, we can definitely prove or disprove a statement by observing whether it comports in all respects with the law. This is the highest order of proof available at present and, strictly speaking, the only unambiguous kind of proof. As Herschel declares: "The grand and indeed only character of truth is its capability of enduring the test of universal experience and coming unchanged out of every possible form of fair discussion." (*Discourse*, [6.]) Next in order follow the large working hypotheses in science which represent provisional laws, and are employed as a staple test.

Although, of course, preferring irrefragable proof, the man of science naturally accommodates himself to whatever degree

¹ "If I might impress any caution upon your minds, it is the utterly conditional nature of all our knowledge—the danger of neglecting the process of verification under any circumstances; and the firm upon which we rest, the moment our deductions carry us beyond the reach of this great process of verification. There is no better instance of this than is afforded by the history of our knowledge of the circulation of the blood in the animal kingdom until the year 1824. In every animal possessing a circulation at all, which had been observed up to that time, the current of the blood was known to take one definite and invariable direction. Now, there is a class of animals called *ascidians*, which possess a heart and a circulation, and up to the period of which I speak no one would have dreamt of questioning the propriety of the deduction that these creatures have a circulation in one direction; nor would anyone have thought it worth while to verify the point. But in that year M. von Hasselt, happening to examine a transparent animal of this class, found to his infinite surprise that after the heart had beat a certain number of times it stopped, and then began beating the opposite way, so as to reverse the course of the current, which returned by-and-by to its original direction. I have myself timed the heart of these little animals. I found it as regular as possible in its periods of reversal: and I know no spectacle in the animal kingdom more wonderful than that which it presents—all the more wonderful that, to this day, it remains a unique fact, peculiar to this class, among the whole animate world. At the same time, I know of no more striking case of the necessity of the verification of even those deductions which seem founded in the widest and safest inductions." (T. H. Huxley, *Twelve Lectures and Essays*, ed. 1908, pp. 13-14.)

² Mill, *Logic*, bk. 3, ch. 4, § 1.

of demonstration is obtainable; but, strange to say, in the cultural sciences verification or proof worthy the name is seldom striven after, robbing the statements there made of all sterling value.

§ 48. "The words 'truth', 'truism', 'rule', 'generalisation', 'uniformity', 'regularity', and 'principles' are all often loosely used as more or less nearly synonymous with the word 'law'. But it is important that they be discriminated from one another, for the word 'law' has become peculiarly specialised. Without stopping to define all of the above terms, it must be said at once that most, if not all, of the so-called laws in the social sciences belong to one of the above categories—that is, they are generalisations, uniformities or principles, rather than laws in the sense in which the physical sciences would use that word. Thus Comte's famous Law of the Three States is only a generalisation; while the so-called law of least effort (that the greatest gain is always sought for the least effort) is really a psychological principle. Now exactness in the use of terms is desirable in science; hence it is important that we inquire into the exact meaning which the word 'law' has acquired in the older sciences—the physical sciences. At first in the physical sciences law meant the manifestation of an outer force, controlling the action of things. But as the passive view of nature came to be given up, it came to mean merely the uniform way in which things occur. Later, under the influence of the growth of the mechanical view of nature, law came to mean a fixed, unchanging, and so necessary relation between forces. The concept of a law of nature thus became deeply tinged with the idea of physical necessity. Indeed, in the physical sciences, it became practically synonymous with physical necessity. Hence the expression 'eternal iron laws', embodying the idea that nature is a theatre of mechanical necessities." (Charles A. Ellwood, *Sociology in its Psychological Aspects*, 1912, pp. 74–75.)

"Wo immer uns Erscheinungen in derselben Form der Aufeinanderfolge oder der Koexistenz entgegentreten, da sprechen wir von einem dieser Gleichförmigkeit zugrunde liegenden Gesetze. Es ist das offenbar nur eine Analogie oder Metapher. Das Urbild desselben ist dem politischen Leben entnommen. Wenn ein Gesetz für bestimmte Fälle die Beobachtung eines bestimmten Vorganges anbefiehlt, so geschieht dieses in allen bezüglichen Fällen in derselben durch das Gesetz vorgeschriebenen Form. Wo wir also in der Natur eine Erscheinung in derselben Form sich wiederholen sehen, da stellen wir uns die Sache der grösseren Verständlichkeit wegen so vor, als ob diese Gleichförmigkeit die Folge irgendeines höheren, in einem Gesetz sich verkörpernden Willens wäre, und sprechen kurzweg von einem Gesetz dieser Erscheinungen. Wir erlangen durch diese Metapher für eine Reihenfolge von Erscheinungen einen leicht verständlichen Ausdruck, eine einfache Formel." (L. Gumplowicz, *Grundriss der Soziologie*, 1905, pp. 103–104.)

"It is the custom in science, wherever regularity of any kind can be traced, to call the general proposition which expresses that regularity a law." (Mill, *Logic*, bk. 3, ch. 4, § 1.)

"We may regard a law of nature either, 1st, as a general proposition, announcing, in abstract terms, a whole group of particular facts relating to the behaviour of natural agents in proposed circumstances; or, 2ndly, as a proposition announcing that a whole class of individuals agreeing in one character agree also in another." (Herschel, *Discourse*, [91].)

Since the term law, in its political acception, incorporates the conception, at the one end, of arbitrary and ruthless decrees and, at the other end historically, of a mature decision by a democratic assembly aiming in a humane manner at the welfare of the whole community, it is indispensable to bear in mind the evolution of political law when interpreting the signification of law in the scientific sense.

SECTION XV.—DEDUCTION.

§ 49. In a generalised statement much is often comprised which was not suspected at first.¹ In consequence, when we have reached our plain generalisation, and have embodied it in a transparent definition, we begin to seek for all that it involves. Here we do not rise from the minor to the major, as in induction, but we descend from the major to the minor. This process is named deduction, and is often of paramount significance. Theoretically we might imagine a complete induction which exhausts every possible aspect, even to the past and the future; in practice, however, comparatively few aspects can be taken into consideration in an enquiry by a single scholar. When, then, a generalisation is proposed or established, we may descend in various ways to groups of particulars. Manifestly, deductive reasoning forms an essential component of the scientific process of investigation, and science would be decidedly the poorer if the deductive process were discarded. *We may define deduction as that portion of a scientific enquiry which, starting from a given statement, seeks to draw out its implications in a desired direction or generally.*

Deduction is especially fruitful and safe where exact and quantitative determinations have been reached. Here the precise form of the generalisation allows of the fullest and minutest deduction, as, for instance, in astronomy and mechanics. Mathematics is, therefore, of increasing value as science progresses, and accordingly, when most developed, science tends to clothe itself in mathematical garb, *i.e.*, tends to become deductive. This is no reflection, as is often assumed, on the inductive and reputedly non-mathematical method, for this method not only prevails, but is necessarily supreme, in all but the last stages of a science. We must be first cognisant of the rudimentary facts yielded by an examination of relevant data, then reach a sufficient number of wide generalisations, then embody these in a crisp definition, and only after this can we securely and with distinct advantage proceed deductively when weighty issues are involved. Hence observation, generalisation, definition, and deduction form interrelated component parts of one method.

Descartes searched in his mind for a clear and distinct idea which he finally imagined that he had discovered. This discovery he expressed in the now celebrated postulate *Cogito*,

¹ "Axioms, duly and orderly formed from particulars, easily discover the way to new particulars, and thus render sciences active." (Bacon, *Novum Organum*, bk. 1, 24.) "All true and fruitful natural philosophy hath a double scale or ladder, ascendent and descendent, ascending from experiments, to the invention of causes; and descending from causes, to the invention of new experiments." (Bacon, *Advancement of Learning*, bk. 2.) And, rightly, "that method of discovery and proof according to which the most general principles are first established, and then intermediate axioms are tried and proved by them, is the parent of error and the curse of all science". (*Novum Organum*, bk. 1, 69.) "The deductive method . . . consists of three operations—

ergo sum. He then proceeded to deduce from this statement the nature of soul and substance, and also the quality of the perfect within man. From these premises he deemed that he was entitled further to evolve an explanation of the varied facts of existence. Next, he turned to verifying his deductions, and here once more he came into contact, if not in collision, with empirical data.¹ The difference, then, between Descartes and modern men of science is only that the latter assign a more prominent position to induction, and not that the one proceeds deductively and the other inductively. Bacon, feeling that he stood at the threshold of science, and that the method of hasty generalisations succeeded by hasty deductions had led to a tangle of erroneous theories, almost denounced the deductive and almost ignored the connected mathematical method;² Descartes, absorbed in mathematical studies, inclined to the other extreme, and restricted the influence of induction wellnigh to a vanishing point. With Descartes will lie the final triumph, but only after Bacon's method shall have paved the way.

the first, one of direct induction; the second, of ratiocination; the third, of verification." (Mill, *Logic*, bk. 3, ch. 11, § 1.) "In deduction the propositions are based on other propositions, not on observations." (Bain, *Logic*, vol. 2, p. 4.)

¹ The writer of the article on Bacon in the *Encyclopædia Britannica* (9th edition), Prof. R. Anderson, harks back to Descartes: "The true scientific procedure is by hypothesis followed up and tested by verification; the most powerful instrument is the deductive method, which Bacon can hardly be said to have recognised." (P. 216, right column.) John Stuart Mill is even more emphatic regarding the deductive method: "To the deductive method", he says, "the human mind is indebted for its most conspicuous triumphs in the investigation of nature." (*Logic*, bk. 3, ch. 11, § 3.) Once again we remark the over-emphasis on the value of hypotheses. Is it, for instance, really true that the problem of the satisfactory construction, ventilation, lighting, heating, sanitation, and acoustics of buildings is merely waiting the advent of the modern medicine man or wizard, the hypothesis maker, and that the study of the apposite facts is very nearly a sheer waste of time and energy? Or would it not be fairer to say that the right hypothesis will emerge only after the most circumstantial and most comprehensive investigation of the facts? Darwin entertained no delusions on this subject: "Concerning Bastian's work, he said, in a letter to Wallace, 'I am not convinced, partly, I think, owing to the deductive cast of much of his reasoning; and I know not why, but I never feel convinced by deduction, even in the case of Herbert Spencer's writings'; and in a letter to John Fiske: 'I find that my mind is so fixed by the inductive method, that I cannot appreciate deductive reasoning; I must begin with a good body of facts, and not from principle (in which I always suspect some fallacy), and then as much deduction as you please.'" (Frank Cramer, *op. cit.*, pp. 34-35.) And again: "'I have steadily endeavoured to keep my mind free so as to give up any hypothesis, however much beloved (and I cannot resist forming one on every subject), as soon as facts are shown to be opposed to it. Indeed, I have had no choice but to act in this manner, for, with the exception of the Coral Reefs, I cannot remember a single first-formed hypothesis which had not after a time to be given up or greatly modified. This has naturally led me to distrust greatly deductive reasoning in the mixed sciences.'" (*Ibid.*, p. 37.)

² See, however, Section XVI, for an extended statement on the subject by Francis Bacon.

Aristotle's syllogism can neither be identified with the inductive nor altogether with the deductive method. This is owing to the fact that not only is the mode of obtaining major premises regarded as alien to the subject, but no provision is made, outside the reasoning process itself, for substantiating the conclusion reached. Strictly speaking, it represents a mode of testing a statement as to its consistency with a more general proposition, and may be said to be applicable where major and minor premise are already demonstrated.¹

Generalisation begins with the examination of the data. With deduction the opposite obtains, *i.e.*, examination principally concerns itself with the verification of the deduction. With this stage reached, the main scientific process of investigation is completed on the theoretical side, save in so far as new investigations are suggested. Jevons truly says: "The investigator begins with facts and ends with them. He uses facts to suggest probable hypotheses; deducing other facts which would happen if a particular hypothesis is true, he proceeds to test the truth of his notion by fresh observations." (*The Principles of Science*, p. 509.)²

¹ For instance, the following would be a correct syllogism:—

All men are immortal;
My dog Cato is a man;
Therefore my dog Cato is immortal.

Or, All multicellular beings are unicellular;
This mathematical point is a multicellular being;
Therefore this mathematical point is unicellular.

² A knowledge of facts makes a profound difference to the nature of a hypothesis and to the possibility of proving it or disproving it with fair ease. We may illustrate this from Arrhenius' theory of panspermia. Desirous of proving that life may have reached our globe from other spheres, he assumes that life might be transferred from world to world in the form of microscopically minute spores. He states that the rate at which such a spore would fall is so small that favourable upward currents of air could waft it upwards a hundred miles, to the limit of our atmosphere. There it might take up negative electricity, and be driven out into interplanetary space by other particles positively charged. Then the radiation pressure of the sun would drive it out into stellar space. Finally, it might find a resting place, after travelling for some thousands of years, and there it might introduce life or augment the existing life. Each step in this theory of Arrhenius, including the assumption of the existence of microscopic spores, is based not on bare suppositions, but on scientific knowledge of the first order, and in this Arrhenius only follows the common practice among scientists. If the spores and the other circumstances had been merely postulated, we should have had an illustration of the ancient and useless conception of a deduction. Mendelyeff's assumption that the ether is a chemical element incapable of forming combinations, is similarly deduced from recent enquiries which indicate that such inert elements exist.

Here are instances where the basis of the reasoning is of a very hypothetical character. "Of supposed structural life units there is a great variety. Besides the gemmules of Darwin, there were the physiological units of Herbert Spencer. Professor Haeckel ... has structural units of his own which he terms plastidules. ... Then came Nägeli, the great botanist, who spoke

On circumspectly examining the scope of deductive procedure, it becomes patent that an investigation conducted according to strict scientific rules involves the application of deduction almost as frequently as that of generalisation. Just as from time to time the investigator pushes his enquiry forward, so he loses no occasion for testing the next step which he proposes to make by sounding its implications. That is, instead of securing all his middle axioms by induction, he arrives at many of them through deduction. Naturally, therefore, when he has reached his final generalisation, and has embodied it in a concise statement, he will not neglect the momentous duty of probing it deductively. Thus deduction is no stranger to generalisation, and by further compelling exactness in statement at every turn, it is of double benefit to him who generalises.

A deduction to be scientifically permissible and serviceable must be grounded on a proposition well rooted in verified data, for without this we are back in the age of scholasticism and obscurantism. In fact, in modern enquiries a large number of verified propositions are commonly employed to enable a single deduction to be made. Theoretically speaking, it might be as convenient to discover classes of facts by going backwards as by proceeding forwards. In practice, however, the reverse is emphatically the case, and this constitutes the justification for seeking for the fullest, as for the most comprehensive, generalisations. For example, by attentively watching an individual who is quick in his ways, we might finally discern the rationale of quickness—"a settled and eager desire to be expeditious, coupled with fair intelligence, study of others who are expeditious, and adequate practice", from which the diverse methods he employs should follow logically. Yet, in reality, the mere knowledge of the statement which subsumes the inductive enquiry would deductively yield with great difficulty a paucity of information, and much of this would be spurious. Granted, however, the inductive statement, and a certain number of the details on which it is based to illustrate its inwardness, and methodised deductive procedure (see Conclusion 31) will yield substantial additions. For the sake, therefore, of deduction, we plead that generalisations shall be as full as possible, in order that the task imposed on it shall not be excessive.

If a deduction needs to be rooted in justifiable generalisations or facts, it must be no less subject to rigid verification, for a merely plausible deduction has no more value than a merely specious generalisation. Deduction, again, is fertile, in proportion

of *Idioplasma-Teilchen*. Then Weisner, also a botanist, who spoke of the *Plassomes*. Our own Prof. Whitman attributed to his life units certain other essential qualities and called them *idiosomes*. A German zoologist, Haake, has called them *gemmales*. Another German writer, a Leipsic anatomist Altmann, calls them *granuli*." (C. S. Minot, *op. cit.*, pp. 234-235.)

as it can depend at every juncture on already verified classes of facts, without which its path leads straight into a morass of idle suppositions, as the last Section has shown.

The layman who does not pretend to originate or exhaustively scrutinise scientific theories, cannot be invited to verify everything he hears, and the chief responsibility rests hence on the experts who are either the inventors or the protagonists of a theory. For instance, during the last generation, a movement has become fairly popular which demands that since natural and artificial selection is the law which governs advance in the animal world, this law should be respected in regard to the human species; and, consequently, this movement maintains, the utmost should be attempted to encourage the fit¹ to produce abundance of offspring and the unfit² to produce none. Taking their stand on this doctrine, some extremists deductively argue that the "lower" races and "lower" classes (according to them four-fifths of mankind perhaps) should be sternly repressed and legislated against, whilst other champions of this view contend that scientific breeding and regimentation should replace marriage and family life. In this place we are only concerned with the initial deduction, and we therefore ask ourselves whether it has been solidly proven that, first, in the animal world generally selection is the principal law, and, secondly, that this law partly or wholly applies to the human world. Assuming the first as settled affirmatively, we may consider it legitimate to infer tentatively that selection should not be disregarded in the human species; but scientific procedure requires proof that the human species does not constitute an exception. This, however, has not been seriously attempted by the teachers and preachers of eugenics, and the position is that, without scientific warrant, grave and far-reaching social proposals are confidently put forward, proposals which withdraw all protection from the poor and give *carte blanche* to the well-to-do. As we have endeavoured to indicate in our Preliminary Considerations and in other places, especially in Conclusion 13, the human individual is primarily adapted for the specio-psychic state, that is, he is part of a complex pan-human civilisation developed through the ages by the inventions and discoveries of the mass of men and women, and perpetuated solely by traditions, imitation, and teaching. Human progress, in consequence, depends first and foremost on cultural, and not on biological, advance. A small dose of Baconian contempt for haphazard and unverified generalisations and deductions would have delivered mankind from this theory and from legions of kindred ones, and methodologists cannot but deplore the many superfluous and extravagant theories which clog the wheel of human progress. It is, therefore, indispensable that

¹ and ² See § 143 for a definition of these terms.

however colourable a deduction may appear to be, it should be scrupulously verified—above all, needless to say, in matters of life and death. The time should have passed when men, in particular scholars and propagandists, are satisfied with a collection, small or large, of affirmative instances or pretentious deductions. We should insist that he who claims to be a specialist, should, as an elementary duty, rigorously verify his observations, generalisations, and deductions.

SECTION XVI.—DEFINITE, EXACT, AND MATHEMATICAL PROCEDURE.

§ 50. (A) *THE CASE FOR MATHEMATICAL PROCEDURE*.—If it be queried why highly developed sciences should tend to assume mathematical form, and why complete absence of mathematical apparatus argues crudity in any sphere of knowledge, the answer is near at hand. The sciences ruled by mathematics appear to be the only exact sciences, and accordingly every science, since it strives to be exact, must needs strive to be mathematical.¹ Out in the world of practice, ideas are protean in character: a new meaning develops out of an old one because a new need has arisen, and this meaning gradually passes, for the same reason, from one shape to another, a single word representing the multifarious meanings. Analyse the terms *morality*, *duty*, *virtue*, *ought*,² for instance, and observe how they alter in signification from age to age, from country to country, and, to some extent, from individual to individual, and even from occasion to occasion. These terms, which are among our current ethical coin, symbolise countless attitudes and actions, and this is approximately true of words in general. Now mathematical procedure rescues us almost totally from this vertiginous chaos. It measures phenomena, and reduces data to a form which is as inflexible and universal as the every-day terminology is accommodating and individual. Once we have reached the mathematical level, it is no longer necessary to define by indefinable terms, or explain by offering equivocal illustrations. We are able then to make statements which it is practically impossible to misconstrue, and which therefore convey precisely the same signification to all persons alike. Hence, perhaps, no science can be said to be fully established so long as it is entirely or even fractionally non-mathematical.

¹ "Inquiries into nature have the best result, when they begin with physics and end in mathematics." (Bacon, *Novum Organum*, bk. 2, 8.)

² "The word represented by 'cause' has sixty-four meanings in Plato and forty-eight in Aristotle. These were men who liked to know as near as might be what they meant; but how many meanings it has had in the writings of the myriads of people who have not tried to know what they meant by it will, I hope, never be counted." (W. K. Clifford, *Lectures and Essays*, ed. 1918, p. 35.)

Clifford lucidly sums up the practical difficulties involved in attaining to complete exactness. We make no apology for quoting him at length: "When a student is first introduced to those sciences which have come under the dominion of mathematics, a new and wonderful aspect of Nature bursts upon his view. He has been accustomed to regard things as essentially more or less vague. All the facts that he has hitherto known have been expressed qualitatively, with a little allowance for error on either side. Things which are let go fall to the ground. A very observant man may know also that they fall faster as they go along. But our student is shown that, after falling for one second in a vacuum, a body is going at the rate of thirty-two feet per second, that after falling for two seconds it is going twice as fast, after going two and a half seconds two and a half times as fast. If he makes the experiment, and finds a single inch per second too much or too little in the rate, one of two things must have happened: either the law of falling bodies has been wrongly stated, or the experiment is not accurate—there is some mistake. He finds reason to think that the latter is always the case; the more carefully he goes to work, the more of the error turns out to belong to the experiment. Again, he may know that water consists of two gases, oxygen and hydrogen, combined; but he now learns that two pints of steam at a temperature of 150° centigrade will always make two pints of hydrogen and one pint of oxygen at the same temperature, all of them being pressed as much as the atmosphere is pressed. If he makes the experiment, and gets rather more or less than a pint of oxygen, is the law disproved? No; the steam was impure, or there was some mistake. Myriads of analyses attest the law of combining volumes; the more carefully they are made, the more nearly they coincide with it. The aspects of the faces of a crystal are connected together by a geometrical law, by which, four of them being given, the rest can be found. The place of a planet at a given time is calculated by the law of gravitation; if it is half a second wrong, the fault is in the instrument, the observer, the clock, or the law; now, the more observations are made, the more of this fault is brought home to the instrument, the observer, and the clock. . . .

At this point we have to make a very important distinction. There are two ways in which a law may be inaccurate. The first way is exemplified by that law of Galileo which I mentioned just now: that a body falling *in vacuo* acquires equal increase in velocity in equal times. No matter how many feet per second it is going, after an interval of a second it will be going thirty-two more feet per second. We now know that this rate of increase is not exactly the same at different heights, that it depends upon the distance of the body from the centre of the earth; so that the law is only approximate; instead of the increase of velocity being exactly equal in equal times, it itself increases very slowly as the body falls. We know also that this variation of the law from the truth is too small to be perceived by direct observation on the change of velocity. But suppose we have invented means for observing this, and have verified that the increase of velocity is inversely as the squared distance from the earth's centre. Still the law is not accurate; for the earth does not attract accurately towards her centre, and the direction of attraction is continually varying with the motion of the sea; the body will not even fall in a straight line. The sun and the planets, too, especially the moon, will produce deviations; yet the sum of all these errors will escape our new process of observation by being a great deal smaller than the necessary errors of that observation. But when these again have been allowed for, there is still the influence of the stars. In this case, however, we only give up one exact law for another. It may still be held that if the effect of every particle of matter in the universe on the falling body were calculated according to the law of gravitation, the body would move exactly as this calculation required. And if it were objected that the body must be slightly magnetic or diamagnetic, while there are magnets not an infinite way off; that a very minute repulsion, even at sensible distances, accom-

panies the attraction; it might be replied that these phenomena are themselves subject to exact laws, and that when all the laws have been taken into account, the actual motion will exactly correspond with the calculated motion. . . .

"The word 'exact' has a practical and a theoretical meaning. When a grocer weighs you out a certain quantity of sugar very carefully and says it is exactly a pound, he means that the difference between the mass of the sugar and that of the pound weight he employs is too small to be detected by his scales. If a chemist had made a special investigation, wishing to be as accurate as he could, and told you this was exactly a pound of sugar, he would mean that the mass of the sugar differed from that of a certain standard piece of platinum by a quantity too small to be detected by his means of weighing, which are a thousandfold more accurate than the grocer's. But what would a mathematician mean, if he made the same statement? He would mean this. Suppose the mass of the standard pound to be represented by a length, say a foot, measured on a certain line; so that half a pound would be represented by six inches, and so on. And let the difference between the mass of the sugar and that of the standard pound be drawn upon the same line to the same scale. Then, if that difference were magnified an infinite number of times, it would still be invisible. This is the theoretical meaning of exactness; the practical meaning is only very close approximation; how close, depends upon the circumstances. The knowledge, then, of an exact law in the theoretical sense would be equivalent to an infinite observation. I do not say that such knowledge is impossible to man, but I do say that it would be absolutely different in kind from any knowledge that we possess at present." (*Op. cit.*, pp. 27-29)

The argument in favour of the preferability of mathematical procedure in science is therefore complete. As Lord Kelvin says: "In physical science a first essential step in the direction of learning any subject is to find principles of numerical reckoning and practicable methods for measuring some quality connected with it. I often say that when you can measure what you are speaking about, and express it in numbers, you know something about it; but when you cannot measure it, when you cannot express it in numbers, your knowledge is of a meager and unsatisfactory kind: it may be the beginning of knowledge, but you have scarcely, in your thought, advanced to the stage of *science*, whatever the matter may be." (*Constitution of Matter*, 1891, pp. 80-81.) Yet much may be accomplished without recondite mathematical formulæ. We have it on Jevons' authority that Faraday "has made the most extensive additions to human knowledge without passing beyond common arithmetic". (*Principles of Science*, p. 579.) And Tyndall, who concurs in Jevons' estimate concerning Faraday's lack of mathematical equipment, says of him: "Taking him for all in all, I think it will be conceded that Michael Faraday was the greatest experimental philosopher the world has ever seen." (*Faraday as a Discoverer*, p. 147.) It should not be supposed, therefore, that every distinguished discoverer is *ipso facto* a great mathematician, or, to consider the reverse side of the shield, that there is no extensive scope for measurement and computation in the ordinary practical affairs of life.

§ 51. The case for measurement can be perhaps best stated by allowing an old writer, the founder of methodology, one who has been regarded as unfriendly to mathematics, to speak (Bacon, *Novum Organum*, bk. 2, 44, 45, and 46): "The chief cause of failure in operation (especially after natures have been diligently investigated) is the ill determination and measurement of the forces and actions of bodies. Now the forces and actions of bodies are circumscribed and measured, either by distances of space, or by moments of time, or by concentration of quantity, or by predominance of virtue; and unless these four things have been well and carefully weighed, we shall have sciences, fair perhaps in theory, but in practice inefficient." "The powers and motions of things act and take effect at distances, not indefinite or accidental, but finite and fixed; so that to ascertain and observe these distances in the investigation of the several natures is of the greatest advantage. . . . But whether the distances at which these powers act be great or small, it is certain that they are all finite and fixed in the nature of things, so that there is a certain limit never exceeded; and a limit which depends either on the mass or quantity of matter in the bodies acted on; or on the strength or weakness of the powers acting; or on the helps or hindrances presented by the media in which they act; all which things should be observed and brought to computation. Moreover, the measurements of violent motions (as they are called), as of projectiles, guns, wheels, and the like, since these also have manifestly their fixed limits, should be observed and computed." "All these things with their measures should in the investigation of nature be explored and set down, either in their certitude, or by estimate, or by comparison as the case will admit." "All motion or natural action is performed in time; some more quickly, some more slowly, but all in periods determined and fixed in the nature of things. Even those actions which seem to be performed suddenly and (as we say) in the twinkling of an eye, are found to admit of degree in respect of duration. First, then, we see that the revolutions of heavenly bodies are accomplished in calculated times; as also the flux and reflux of the sea. The motion of heavy bodies to the earth, and of light bodies towards the heavens, is accomplished in definite periods, varying with the bodies moved and the medium through which they move. The sailing of ships, the movements of animals, the transmission of missiles, are all performed likewise in times which admit (in the aggregate) of measurement. As for heat, we see boys in winter time bathe their hands in flame without being burned, and jugglers by nimble and equable movements turn vessels full of wine or water upside down and then up again, without spilling the liquid; and many other things of a similar kind. The compressions also and expansions and eruptions of bodies are performed, some more slowly, according to the nature of

the body and motion, but in certain periods. Moreover, in the explosion of several guns at once, which are heard sometimes to the distance of thirty miles, the sound is caught by those who are near the spot where the discharge is made, sooner than by those who are at a greater distance. Even in sight, whereof the action is most rapid, it appears that there are required certain moments of time for its accomplishment; as is shown by those things which by reason of the velocity of their motion cannot be seen—as when a ball is discharged from a musket. For the ball flies past in less time than the image conveyed to the sight requires to produce an impression.”

The application of the higher mathematics to science evidently had its origin in the difficulties encountered in direct measurement, difficulties which made recourse to complex calculations inevitable.¹ On this subject also, we venture to quote Bacon. This will serve a double purpose, demonstrating both the high scientific and philosophic status of mathematics, and their generous appreciation by Bacon. The gay medievalism of the style renders the more remarkable the sober modernity of the conceptions embodied therein.

“There remaineth yet another part of natural philosophy, which is commonly made a principal part, and holdeth rank with physic special, and metaphysic, which is mathematic; but I think it more agreeable to the nature of things, and to the light of order, to place it as a branch of metaphysic: for the subject of it being quantity, not quantity indefinite, which is but a relative, and belongeth to *philosophia prima*, as hath been said, but quantity determined, or proportionable, it appeareth to be one of the essential forms of things; as that that is causative in nature of a number of effects; insomuch as we see, in the schools both of Democritus and Pythagoras, that the one did ascribe Figure to the first seeds of things, and the other did suppose Numbers to be the principles and originals of things; and it is true also, that of all other forms, as we understand forms, it is the most abstracted and separable from matter, and therefore most proper to metaphysic; which hath likewise been the cause why it hath been better laboured and enquired, than any of the other forms, which are more immersed in matter.

“For it being the nature of the mind of man (to the extreme prejudice of knowledge) to delight in the spacious liberty of generalities, as in a champaign region, and not in the inclosures of particularity; the mathematics of all other knowledge were the goodliest fields to satisfy the appetite.

“The Mathematics are either pure or mixed. To the pure mathematics are those sciences belonging which handle quantity

¹ A comprehensive survey of this problem will be found in Léon Brunschvicg's work already cited.

determinate, merely severed from any axioms of natural philosophy; and these are two, Geometry and Arithmetic; the one handling quantity continued, and the other dissevered. Mixed hath for subject some axioms or parts of natural philosophy, and considereth quantity determined, as it is auxiliary and incident unto them.

"For many parts of nature can neither be invented with sufficient subtilty, nor demonstrated with sufficient perspicuity, nor accommodated unto use with sufficient dexterity, without the aid and the intervening of the mathematics; of which sort are perspective, music, astronomy, cosmography, architecture, enginery, and divers others.

"In the mathematics I can report no deficiency, except it be that men do not sufficiently understand the excellent use of the pure mathematics, in that they do remedy and cure many defects in the wit and faculties intellectual. For, if the wit be dull, they sharpen it; if too wandering, they fix it; if too inherent in the sense, they abstract it. So that as tennis is a game of no use in itself, but of great use in respect it maketh a quick eye, and a body ready to put itself into all postures; so in the mathematics, that use which is collateral and intervenient, is no less worthy than that which is principal and intended." (*Advancement of Learning*.)

§ 52. (B) DEFINITION OF TERMS.—However, a bridge exists connecting mathematical rigidity with commonsense fluidity. This bridge comes into being so soon as a science commences to define its terms with fair precision, and makes itself thus independent of a fluctuating terminology.

Where the conceptions are, as in physics, of severe simplicity, it is frequently practicable to define them, though not without having to allow for the ambiguities incidental to the complexity of objects and to the readjustments necessitated by new discoveries. Every science must thus aim at evolving a terminology of its own where each term is unequivocally defined, and a science is therefore progressing indifferently when it is without a terminology which is being fashioned more and more to assume the form of a series of unvarying and universally accepted definitions, as in the nomenclature of chemistry and the terminology of botany. It is patent that we cannot satisfactorily define what we are acquainted with only imperfectly, and that if knowledge can only be acquired by degrees, a definition cannot be flawless all at once, but must grow in exactitude. For this reason, the least advanced sciences are in a sorry predicament. This is particularly noticeable where the terminology of a science is bodily transferred from the every-day terminology; and the evil reaches the highwater mark when the tacit assumption prevails, as in psychology and ethics, that the terminology of the market place is substantially satisfactory, and that there is consequently no need for its improvement

or definition.¹ Such an attitude is manifestly erroneous. Rather should there be from the very first the most determined resolve to define terms as accurately as possible, to ensure that the term is comprehensive in meaning, and to remodel the definitions incessantly according to need. The indeterminateness of language constitutes one of the weightiest reasons for pressing an enquiry to the furthest limits practicable in order to obtain the maximum of clearness and definiteness, and this indeterminateness presents also the heaviest indictment against a loose or undefined use of terms in science. Ideally speaking, therefore, individual investigations pertaining to a new science should extend to a life-time, should be pursued with eyes ever vigilant to detect new facts and new relations, and should restlessly aim at an increasingly exact, exhaustive, durable, and convenient terminology. A science, then, commences in perplexing indefiniteness, and tends to terminate in dogmatic definiteness. It is even indispensable that there should be a clear consciousness of the inappropriateness of attempting, at the beginning of a new investigation, to cast the results achieved into a mathematical mould, just as it should be an ambition and aspiration from the first to attain to progressively greater exactitude and, eventually, to mathematical formulation.

§ 53. (C) PRECISION IN STATEMENTS.—If precision in the use of terms is the pre-requisite of accurate scientific activity, precision in general statements is its crowning glory. A vague terminology bewilders the inquirer and gravely impedes advance, and the circumstances are only slightly less disastrous when instead of cautiously framed definitions, we are faced by an interminable series of more or less nebulous generalisations. The methodological ideal is evidently that the material results of an enquiry should be presented (as by Spinoza) in a chain of definitions, accompanied by pithy explanations and a few apt illustrations, because just as in the attempt to define terms exactly, the maximum of error is eliminated, the endeavour precisely to define general truths leads to a degree of reliability in results otherwise scarcely ever attained. Any attempt at consistent definition very speedily reveals that it is one thing to formulate a general statement, and another to shape this statement so faithfully that it should resist critical and minute scrutiny. It is, therefore, essential for the scientific worker to be aiming at definitions from the commencement to the consummation of the enquiry, both because it will clarify and concentrate his thought, and because it will place him in a position to proceed deductively with increased assurance. Indeed, deduction can only be pursued with full confidence and with tolerable success when the scientific worker has been throughout

¹ The advantages are dubious of substituting one series of terms for another virtually equivalent in meaning, as when thinking, feeling, and willing become cognition, affection, and conation.

striving to frame incontrovertible definitions, and when the anterior inductive enquiry is compressed into a definition. Should these epitomised statements, however, be excessively difficult to reach, then definitions as rigid as possible should be the goal of scientific endeavour.

§ 54. (D) DEFINITENESS IN SCIENTIFIC WORK GENERALLY.—This leads us naturally to recognise the need for definiteness generally, leaving no more of the activities in a fog or undetermined than is inevitable. Such an attitude of mind will prick any number of iridescent bubbles which unwarrantably arrest our untrained attention; it will secure that we do not pass to the second stage before the first stage is completed; it will circumvent mountains of errors; and it will ensure a rapid and safe advance.

In a word, a true methodology demands definiteness (a) in terms, (b) in general statements, and (c) in work generally, requiring mathematical treatment wherever practicable. *Procedure may be said to be exact when it is mathematical, and when definiteness is aimed at in terms, in statements, and in work generally.*

§ 55. (E) MATHEMATICAL AND NON-MATHEMATICAL PROCEDURE.—To conclude. In view of the opinion which widely obtains that mathematics is separated, as it were, by a gulf from the inductive sciences through its abstractness, its irresistible demonstrations, and its mode of procedure, it is interesting to find that, of recent years, three mathematicians have sought to show that no such breach exists. The last of the three utterances is that of Prof. E. W. Hobson, F.R.S., and is contained in his Presidential Address to the Mathematical and Physical Science Section of the British Association in 1910. We shall let him speak:—

“In the first place, it is a fact that frequently, and at various times, differences of opinion have existed among mathematicians, giving rise to controversies as to the validity of whole lines of reasoning and affecting the results of such reasoning; a considerable amount of difference of opinion of this character exists among mathematicians at the present time. In the second place, the accepted standard of rigour, that is, the standard of what is deemed necessary to constitute a valid demonstration, has undergone change in the course of time. Much of the reasoning which was formerly regarded as satisfactory and irrefutable is now regarded as insufficient to establish the results which it was employed to demonstrate. It has even been shown that results which were once supposed to have been fully established by demonstrations are, in point of fact, affected with error.” (*British Association's Report of 1910*, p. 514.) “That oldest text-book of science in the world, Euclid's *Elements of Geometry*, has been popularly held for centuries to be the very model of deductive logical demonstration. Criticism has, however, largely invalidated this view.” (*Ibid.*, p. 516.) “The actual evolution of mathematical theories proceeds by a process of induction strictly analogous to the method of induction employed in building up the physical sciences: observation, comparison, classification, trial, and generalisation are essential in both cases.” (*Ibid.*, p. 520.)

Our second citation is from a paper in a volume entitled *De la méthode dans les sciences*, 1910, contributed by M. J. Tannery, Membre de l'Institut. The importance of the subject must justify our rather lengthy quotation:—

“Comme toutes les autres sciences, les mathématiques se sont développées par l'accroissement des vérités particulières, d'une part, et, de l'autre, par l'acquisition d'idées et de théories de plus en plus générales. Tous les grands géomètres ont eu, à la fois, le goût du particulier et du général, des faits précis et des vastes spéculations; quelques-uns, peut-être, préféraient regarder d'un côté ou de l'autre. Mais le progrès dans un sens s'est toujours mêlé au progrès dans l'autre; d'une part, la connaissance d'une loi générale permet d'atteindre plus de faits particuliers; d'autre part, la généralité d'un raisonnement, d'une méthode, apparaît mieux sur un fait particulier que sur un autre.

“Dire que tout accroissement d'une science résulte de l'état de cette science, au moment où se produit cet accroissement, c'est faire une affirmation bien banale, mais à laquelle on ne donne pas assez d'attention, quand il s'agit des mathématiques, d'autant que toute proposition découverte est rattachée aux axiomes par cela même qu'elle est démontrée, et qu'il semble qu'on aurait pu aussi bien la déduire des axiomes, n'importe quand: cela semble à ceux qui regardent la science faite, non la science qui se fait.

“‘En vain’, dit Galois¹, ‘les analystes voudraient-ils se le dissimuler: ils ne déduisent pas, ils combinent, ils comparent; quand ils arrivent à la vérité, c'est en heurtant de côté et d'autre qu'ils y sont tombés. ...’ (*Ibid.*, pp. 62–63.)

“Dans les diverses sciences, la matière et les instruments diffèrent, la marche de l'invention est la même. Mêmes essais, mêmes tâtonnements, même patience active et tendue, pour ainsi dire, vers un objet qui s'éclaire parfois, mêmes espoirs trompés, même finesse et même imagination pour saisir les analogies, les liens cachés, les rapports inattendus. ... Au mathématicien, quand il a trouvé une loi, on demande plus qu'au physicien; sans doute, celui-ci souhaite rattacher sa loi à une théorie générale; mais le mathématicien *doit* la démontrer; la proposition n'est vraiment acquise, et certaine, que lorsqu'elle a été rattachée aux axiomes. Il est fort remarquable qu'on ait donné le nom d'*induction* à l'un des procédés de démonstration, qui consiste à découvrir dans l'énoncé une nécessité interne telle qu'il ne peut être vrai quelquefois sans l'être toujours: les expériences où on l'a trouvé vrai suffisent à l'entière certitude. Il y a de très beaux exemples de ce mode de démonstration.

“Sans doute, ce n'est pas toujours d'une façon directe que l'on applique la méthode expérimentale en mathématiques. Il reste vrai que la science acquise, telle qu'il la possède, fournit au mathématicien une matière et des instruments très puissants d'observation et de transformation. Que de calculs numériques auraient été impossibles sans un instrument aussi merveilleux que la numération décimale! Que de ressources apportent les méthodes de calcul algébrique, de calcul intégral, les transformations géométriques! Que de moyens pour rapprocher l'inconnu du connu, pour éclairer l'un au moyen de l'autre, pour changer une vérité en une autre, pour reconnaître l'identité de propositions qui semblaient, tout d'abord, ne pas appartenir au même domaine! Et ces moyens s'accroissent d'année en année, se perfectionnent, deviennent plus aisés à manier, se compliquent, permettent d'atteindre plus loin.

“La matière à ouvrir ne manque pas et ne manquera jamais.

“On peut faire des progrès utiles, parfois importants, en cherchant à mieux connaître ce qui est déjà connu, en appliquant des méthodes connues

¹ Manuscrits et papiers inédits de Galois. (*Bulletin des sciences mathématiques*, 2^e série, t. XXX, p. 260.)

à des faits connus. Certaines propositions apparaissent d'abord comme isolées, ou bien l'on ne sait y parvenir que par un seul chemin; ou encore on ne sait déduire que d'une façon une suite de propositions. Pour relier ces propositions ou ces théories isolées, pour y parvenir par des voies nouvelles, pour multiplier les chemins de traverse, le travailleur dispose parfois de méthodes plus puissantes que celles dont ses prédécesseurs ont dû se contenter; il peut trouver des voies plus directes, des démonstrations plus simples, et rencontrer, chemin faisant, quelque fait important sur lequel l'attention n'avait pas été attirée. Les travaux de cette nature, si même ils sont modestes, contribuent à l'organisation de la science. Ils peuvent avoir un caractère très élevé et témoigner, chez leur auteur, d'une rare imagination mathématique." (*Ibid.*, pp. 65-67.)

"Par l'observation et la comparaison des propriétés déjà connues des fonctions ou des figures, par la réflexion attentive sur ce connu, des questions se posent au travailleur: quelques-unes se posent naturellement. Elles sont, par exemple, résolues pour certaines fonctions ou certaines figures, comment ne pas se les poser pour d'autres fonctions ou d'autres figures, dont on connaît déjà quelques propriétés? Les unes sont plus ou moins aisées à résoudre, ou à aborder, par des méthodes connues, et les faits particuliers s'accumulent ainsi. D'autres restent ouvertes pendant des siècles.

"Les questions s'enchaînent, se généralisent, se multiplient." (*Ibid.*, p. 68.)

"Que dire du génie d'invention, de l'imagination créatrice? On ne s'attend pas à ce que j'essaie d'en esquisser la psychologie.¹ Voici, autant qu'on en peut juger par les œuvres des grands géomètres, quelques-uns de ses efforts et de ses résultats, et cette énumération ne sera qu'un résumé de ce que je me suis efforcé de décrire plus haut: Découvrir de nouveaux liens entre les choses, attaquer des questions déjà posées avec les méthodes perfectionnées que fournissent les progrès de la science, préciser un problème qui, peut-être, était implicitement contenu dans les travaux antérieurs, lui donner 'une forme telle qu'il soit toujours possible de la résoudre',² pressentir la solution et y parvenir, choisir les questions qui auront une grande portée, deviner cette portée, saisir, dans le pâle reflet qu'il laisse sur les faits particuliers le rayonnement d'une théorie générale, s'élever jusqu'à cette théorie, jusqu'au point où les faits qui ont permis de la découvrir ne sont plus qu'une infime partie du monde de vérités qu'elle illumine. . . . Les exemples de pareilles découvertes ne manquent pas dans l'histoire des mathématiques, et notre temps n'en a pas été privé." (*Ibid.*, p. 71.)

"En s'organisant, les mathématiques tendent vers une forme déductive plus parfaite. Mais ne peut-on en dire autant des autres sciences?" (*Ibid.*, p. 72.)

M. Poincaré (*Science et méthode*, 1908, p. 2) defends the same standpoint: "Le mécanisme de l'invention mathématique ne diffère pas sensiblement du mécanisme de l'invention en général."

SECTION XVII.—INDUCTION.

§ 56. John Stuart Mill proposes several definitions of the term Induction. He tells us that "Induction may be defined as the operation of discovering and proving general propositions". (*Logic*, bk. 3, ch. 1, § 2.) This would, therefore, in-

¹ On trouvera dans *Science et méthode* de M. H. Poincaré (p. 43) un chapitre extrêmement intéressant sur ce sujet.

² Abel, *Œuvres*, Ed. Sylow, t. II, p. 217.

clude, according to our examination, the process of perceiving objects, that of observing and experimenting with or without instruments, that of generalising, and, finally, that of verifying and exhausting our generalisations through deductive procedure and otherwise. We could not adopt another definition of Mill's which conceives induction to be conterminous with generalisation, as when he states: "Induction is the process by which we conclude that what is true of certain individuals of a class is true of the whole class, or that what is true at certain times will be true in similar circumstances at all times"¹ (*ibid.*, bk. 3, ch. 2, § 1); but we do appreciate the fact that generalising—or induction, as Mill names it—if it be guarded and yet not deficient in daring, is relatively the most useful, because most far-reaching, portion of the process of induction. The first definition prevents the confounding of the two terms Generalisation and Induction, and assigns a distinctive meaning to each of those terms; yet even this definition is not sufficiently comprehensive, since it is not identical with an enquiry as such.

It is difficult to define truly the process of induction, save perhaps by such an ambiguous phrase, as that *Induction sums up the general method of procedure in modern science.*² The pre-scientific practice was to draw conclusions from insufficient

¹ In Mill's opinion induction implies an inference from certain particulars to a class. For this reason, when *all* the particulars are given, we have, according to him, "Inductions improperly so called". He thus identifies induction with the more common form of generalising, and leaves no term to denominate the scientific process as such.

² Induction is "a kind of argument which infers, respecting a whole class, what has been ascertained respecting one or more individuals of that class". (Whately, *Logic*, p. 344.)

"The contrast of the deductive and inductive process is obvious. In the former, we proceed at each step from general truths to particular applications of them; in the latter, from particular observations to a general truth which includes them." (Whewell, *History of Scientific Ideas*, vol. 1, p. 28.) "Each induction supplies the materials of fresh inductions, each generalisation, with all that it embraces in its circle, may be found to be but one of many circles, comprehended within the circuit of some wider generalisation." (*Ibid.*, p. 50.) "The process of induction may be resolved into three steps: the selection of the idea, the construction of the conception, and the determination of the magnitudes." (*Novum Organon Renovatum*, p. 186.)

"Induction is the arriving at general propositions, by means of Observation or Fact." (Bain, *Logic*, vol. 2, p. 111.) "Induction so-called is merely a certain collection of particulars, with generalised expression superadded; deduction is the bringing in of new particulars." (*Ibid.*, p. 419.)

"There are but three steps in the process of induction: (1) Framing some hypothesis as to the character of the general law. (2) Deducing consequences from that law. (3) Observing whether the consequences agree with the particular facts under consideration." (Jevons, *Principles of Science*, pp. 265-266.) "In all cases of inductive inference we must invent hypotheses, until we fall upon some hypothesis which yields deductive results in accordance with experience." (*Ibid.*, p. 228.)

"Every process of induction and deduction may be broadly described as a cognition and a recognition." (Naden, *Induction and Deduction*, p. 92.)

and generally spurious evidence, or lightly to postulate a general truth or law of nature and recklessly to deduce consequences. To-day facts are closely scrutinised, cautiously generalised, and, in this form, utilised for deductive ends. *Induction* is, therefore, *the process of discovering and proving general propositions which summarise an enquiry*, rather than the discovery and proof of generalisations as such. One should even, as we have done, include the process of deduction in the definition, because deduction, as an integral component of the general process of

"Induction is a process of cognition involving recognitions. Deduction is a process of recognition involving cognitions." (*Ibid.*, p. 100.)

"Induction, then, is the reference to reality of a system on the ground of particular differences within it by which reality is taken as qualified." (Bosanquet, *Logic*, vol. 2, p. 179.)

"Der Ausdruck Induction wird im eigentlichsten und strengsten Sinne dann gebraucht, wenn von dem Einzelnen, das sich durch Beobachtung feststellen lässt, auf das Allgemeine geschlossen wird." (Überweg, *System der Logik*, p. 371.)

"The inductive methods, it is certain, are the most effectual helps to the attainment of new truth, but it is no less certain that they rest entirely on the results of deductive logic." (Lotze, *Logic*, vol. 2, p. 22.)

"Induction is the operation by which we pass from the knowledge of facts to those of the laws which rule them." (Lachelier, *Du fondement de l'induction*, Paris, 1896, p. 3.)

"The process of induction [is] the method of obtaining universal propositions from particular perceptions." (Sigwart, *Logic*, vol. 2, p. 288.)

"Nach dem Grad der Allgemeinheit . . . können wir nun drei Stufen der Induction unterscheiden: (1) Die Auffindung empirischer Gesetze; (2) die Verbindung einzelner empirischer Gesetze zu allgemeineren Erfahrungsgesetzen; endlich (3) die Ableitung von Kausalgesetzen und die logische Begründung der Tatsachen." (Wundt, *Logik*, vol. 2, p. 25.)

"Inductive logic aims at understanding and classifying the methods of the sciences." (Mellone, *Introductory Text-book of Logic*, 1905, p. 245.)

"The essential steps in the inductive method are: (1) The formation of a hypothesis suggested by a first observation of facts. (2) The deduction of the consequences of this hypothesis. (3) The testing of these consequences by a careful analysis of phenomena. (4) The consequent exact definition of the hypothesis, which then, as expressing the true universal nature of reality, is verified and received as an established theory or law." (James Welton, *A Manual of Logic*, vol. 2, p. 60.)

"Induction may be defined as the legitimate inference of the unknown from the known. . . . Induction is not only an inference of the unknown from the known; but, in virtue of that fact, of the general from the particular." (Thomas Fowler, *Logic, Deductive and Inductive*, vol. 2, pp. 9-10.)

"Die Induction ist nicht der Weg zu den nothwendigen Wahrheiten, sondern der Weg zu der Verbindung der nothwendigen Wahrheiten mit den zufälligen Wahrheiten." (E. F. Apelt, *Die Theorie der Induction*, 1854, p. 56.)

(See also A. C. Mukerji, *A Text-Book of Inductive Logic*, 1914; E. L. Hawkins, *The Oxford Handbook of Logic, Deductive and Inductive*, 1913; A. K. Trivedi, *Studies in Inductive Logic*, 1914; A. C. Mitra, *The Principles of Logic, Deductive and Inductive*, 2 vols., 1912; A. Subrahmanyam, *Logic, Inductive and Deductive*, 1911; J. Dastets, *Logic, Inductive and Deductive*, 1905; J. Coffey, *The Science of Logic*, 2 vols., 1912; W. R. Boyce Gibson, *The Problem of Logic*, 1908; Paul Natorp, *Die logischen Grundlagen der exacten Wissenschaften*, 1910; A. Gratry, *Logique*, 2 vols., 1868; W. Minto, *Logic, Inductive and Deductive*, 1893; J. Welton, *Groundwork of Logic*, 1917; Carveth Read, *Logic, Deductive and Inductive*, 1906.)

scientific discovery, cannot be justifiably dissociated from induction, especially if it originates in established generalisations and terminates in verification. So long as some men relied on sagacity, instinct, or other mysterious properties of the mind, for the purpose of arriving at a conclusion and utilising it, in an equally magical manner, for deductive ends, and other men diligently sought for general truths only by mechanically producing complete enumerations, a contrast and a separation were possible; but in our day there can only be, in harmony with practical necessities, a question of varying emphasis on these two instruments of thought. The fundamental conception underlying both terms may be said, therefore, to be the systematic and conscientious reliance on, and exploitation of, direct experience according to the most recent and most refined methods of enquiry. It is to be hoped, therefore, that the presumed independence of, and rivalry between, the two primal elements of the one scientific process will soon be regarded as apparent rather than as real.¹

§ 57. Macaulay denies all originality to Bacon, the founder of the inductive method. He declares: "The inductive method has been practised ever since the beginning of the world by every human being. It is constantly practised by the most ignorant clown, by the most thoughtless schoolboy, by the very child at the breast. That method leads the clown to the conclusion that if he sows barley he shall not reap wheat. By that method a schoolboy learns that a cloudy day is the best for catching trout. The very infant, we imagine, is led by induction to expect milk from his mother or nurse, and none from his father." (*Essays*, ed. 1885, p. 407.) He even ventures so far as to aver that the plain man has nothing to learn from Bacon's presentation of that method. He furnishes this amusing instance: "A plain man finds his stomach out of order. He never heard Lord Bacon's name. But he proceeds in the strictest conformity with the rules laid down in the second book of the *Novum Organum*, and satisfies himself that mince pies have done the mischief. 'I ate minced pies on Monday and Wednesday, and I was kept awake by indigestion all night.' This is the *comparentia ad intellectum instantiarum convenientium*. 'I did not eat any on Tuesday and Friday, and I was quite well.' - This is the *comparentia instantiarum in proximo quæ natura data privantur*. 'I ate very sparingly of them on Sunday, and was very slightly indisposed in the evening. But on Christmas-day I almost dined on them, and was so ill that I was in great danger.' This is the *comparentia instantiarum secundum magis et minus*. 'It cannot have been the brandy which I took with them. For I have drunk brandy daily for years without being the worse for it.'

¹ Comte uses the word Generalisation and Systematisation in the place of Induction and Deduction.

This is the *rejectio naturarum*. Our invalid then proceeds to what is termed by Bacon the *Vindemiatio*, and pronounces that minced pies do not agree with him."¹ (*Ibid.*, p. 407.) And a little further down he dismisses Bacon in this manner: "His rules are quite proper; but we do not need them, because they are drawn from our own constant practice." (*Ibid.*, p. 408.)

If Macaulay's remarkable illustration be typical of the way men reason, Bacon was certainly altogether overrating the value of his efforts, but, in truth, the plain man does not reason in such matters once in a hundred times in accordance with Bacon's precepts.

Huxley appears to echo Macaulay: "You have all heard it repeated, I daresay, that men of science work by means of induction and deduction, and that by the help of these operations, they, in a sort of sense, wring from nature certain other things which are called natural laws and causes, and that out of these, by some cunning skill of their own, they build up hypotheses and theories. And it is imagined by many that the operations of the common mind can be by no means compared with these processes, and that they have to be acquired by a sort of special apprenticeship to the craft. To hear all these large words you would think that the mind of a man of science must be constituted differently from that of his fellow-men; but if you will not be frightened by terms, you will discover that you are quite wrong, and that all these terrible apparatus are being used by yourselves every day and every hour of your lives. . . .

"A very trivial circumstance will serve to exemplify this. Suppose you go into a fruiterer's shop, wanting an apple. You take up one, and, on biting it, you find it is sour; you look at it, and see that it is hard and green. You take up another one, and that too is hard, green, and sour. The shopman offers you a third; but, before biting it, you examine it, and find that it is hard and green, and you immediately say that you will not have it, as it must be sour, like those that you have already tried.

"Nothing can be more simple than that, you think; but if you will take the trouble to analyse and trace out into its logical elements what has been done by the mind, you will be greatly surprised. In the first place, you have performed the operation of induction. You found that, in two experiences, hardness and greenness in apples went together with sourness. It was so in the first case, and it was confirmed by the second. True, it is a very small basis, but still it is enough to make an induction from: you generalise the facts, and you expect to find sourness in apples where you get hardness and greenness. You found upon that a general law that all hard and green apples are sour; and that, so far as it goes, is a perfect induction. Well, having got your natural law in this way, when you are offered another apple, which you find is hard and green, you say: 'All hard and green apples are sour; this apple is hard and green, therefore this apple is sour.' That train of reasoning is what logicians call a syllogism, and has all its various parts and terms—its major premiss, its minor premiss, and its conclusion. And, by the help of further reasoning, which, if drawn out, would have to be exhibited in two or three other syllogisms, you arrive at your final determination 'I will not have that apple'. So that, you see, you have, in the first place, established a law by induction,

¹ "Look over the induction, and it will appear that the case is not made out; an exclusion is wanting: it may have been the mixture of minced pies and brandy which did the mischief." (A. De Morgan, *Formal Logic*, 1847, p. 218.) De Morgan challenges Macaulay's reasoning throughout. See the above work, pp. 218-224.

and upon that you have founded a deduction, and reasoned out the special conclusion of the particular case. Well now, suppose, having got your law, that at some time afterwards you are discussing the qualities of apples with a friend, you will say to him, 'It is a very curious thing, but I find that all hard and green apples are sour!' Your friend says to you, 'But how do you know that?' You at once reply: 'Oh, because I have tried them over and over again, and have always found them to be so.' Well, if we were talking science instead of common sense, we should call that an experimental verification. And, if still opposed, you go further, and say: 'I have heard from the people in Somersetshire and Devonshire, where a large number of apples are grown, that they have observed the same thing. It is also found to be the case in Normandy, and in North America. In short, I find it to be the universal experience of mankind wherever attention has been directed to the subject.' Whereupon your friend, unless he is a very unreasonable man, agrees with you, and is convinced that you are quite right in the conclusion you have drawn. He believes, although, perhaps, he does not know he believes it, that the more extensive verifications are—that the more frequently experiments have been made, and results of the same kind arrived at—that the more varied the conditions under which the same results are attained, the more certain is the ultimate conclusion, and he disputes the question no further. He sees that the experiment has been tried under all sorts of conditions, as to time, place, and people, with the same result; and he says with you, therefore, that the law you have laid down must be a good one, and he must believe it.

"In science we do the same thing—the philosopher exercises precisely the same faculties, though in a much more delicate manner. In scientific inquiry it becomes a matter of duty to expose a supposed law to every possible kind of verification, and to take care, moreover, that this is done intentionally, and not left to a mere accident, as in the case of the apples. And in science, as in common life, our confidence in a law is in exact proportion to the absence of variation in the result of our experimental verifications." (*Twelve Lectures and Essays*, ed. 1915, pp. 39–41.)

First of all, note the fact that the effects of eating mince pies are notorious; and that, therefore, the argument begs the question. Secondly, a "plain man" who remembered all apposite facts so completely and correctly, would be looked upon as a nine days' wonder among plain men. Thirdly, as De Morgan had pointed out, the plain man did not consider the effect of a mixture in the diet. The following instance, perhaps, more nearly typifies unaided reasoning concerning matters unknown, and betokens simultaneously where Bacon's rules are sinned against. Some one—typifying vast multitudes—had recourse to a certain universal patent medicine for a certain ailment and recovered; therefore that patent medicine, he tacitly concluded, had cured him and will cure everybody of all ailments. Some other universal patent medicine which he had tried previously to this one, was not connected, so he surmises, with his recovery, therefore all other patent medicines are ineffective, if not injurious. Or to mention a humorous case cited in an English court of law during 1914: A typhoid patient having recovered despite of eating herrings, a medical student entered in his diary the words: "Herring cures typhoid." Shortly afterwards, whilst in France, this same student benevolently prescribed

herring to a typhoid patient. On the latter dying, he made a further entry: "Herring cures typhoid in England, but not in France."¹

§ 58. To consider a more important problem. Some one does not sleep well, and desires to ascertain the cause. Does he sleep perhaps too much or too little? Is he too warm or too cold in bed? Are the bed-clothes too heavy? Is there insufficient or too much fresh air in the room? Does he breathe under the bed-clothes? Does he eat or drink too much or too little, or too late, or not late enough at night? Do the meat, the vegetables, the cheese, the bread, the milk, the coffee, or the condiments, disagree with him? Has he insufficient or too much open-air exercise? Is he over- or under-worked, or has he anxieties, or is he consumed by ennui? Is his health impaired? Etc., etc. Pity the man who will trust solely to experiment in such a circumstance, or rush to a conclusion! Yet if he will consult his medical adviser, he will probably obtain a satisfactory reply in a few minutes, for such is the power of science, even an imperfect science like medicine. However, his many questions are themselves reflections of scientific conceptions which the truly "plain man" is without. Not always have we mince pies to aid us in arriving at a conclusion.

Or let us submit a problem dealt with by Dr. Fishberg, a model investigator—the stature of the Jews. Comparing the average height of the Jews with the average height of the contemporaneous population of Europe, we find that the Jews are short of stature. Yet the problem is not so simple. Were the ancestors of the Jews short? Should we not allow for the fact that the conscripts measured had not grown to full stature? Since the Jews are mostly town-dwellers, may this not account for the shortness? May not their indoor occupation of a sedentary character, stunt them? And are not the poverty and privation which exist among so considerable a percentage of the Jews conducive to short stature? Since Jews do not dwell in large numbers in countries where the stature of man is relatively high, is it not feasible that in a general estimate they should appear nearer the bottom of the scale? Ought we not to remember that Jews of different countries vary in height relatively to the general population of those countries? And does not consumption preferably attack the taller Jews, and therefore tend to shorten average stature?

In the same cautious spirit, Dr. Fishberg investigates various other alleged physical and mental characteristics of the Jews,

¹ The illustrations which Macaulay supplies appear to show that he was in need of Bacon's Canons. Because some boys learn that a cloudy day is the best for trout catching, it does not follow that all boys learn it, nor that schoolboys do not transgress countless times against Bacon's rules. Macaulay's reasoning here is a fair example of precipitate inference, which respect for Bacon's methods would have obviated.

showing the un-Baconian reasoning which commonly obtains on this subject.

Let us examine an almost critical instance. Before 1884 the personnel of the Japanese navy suffered cruelly from the disease known as beri-beri. The ratio of illness from beri-beri per 100 of the force during 1878 to 1883 was 32.80, 38.93, 34.81, 25.06, 40.45, 23.12. "In 1882, when there was a prospect of war with Korea, most of the crews of the five largest ships of war in the Japanese navy were prostrated with the disease. . . . The victims often suffered from three to four times a year from the disease." In the following year, on a long cruise of a Japanese warship, "there developed on the voyage over one hundred cases of the disease out of less than 350 persons on board". But beri-beri is found outside the navy. The army had its liberal share of the affliction, and so had the general population. The disease is very frequent with pregnant women, and is most prevalent in summer. The "plain man" was baffled. Not so Doctor Takaki, Surgeon-General of the Japanese navy. "He noticed the great disproportion between the number of cases occurring on warships and those in barracks, and he thought this might result from the difference between the food supplied aboard ship and that supplied ashore." On examination he found "that the proportion of carbo-hydrates in the food was in excess of the requirements, and that the proteids were deficient".¹ He made an experiment. He persuaded the admiralty to despatch a vessel of the same type as the warship mentioned, on the same long voyage, but with a new dietary. The result was that when the *Takauba* reached Honolulu on her return trip, she had three cases, as against 125 cases of the first vessel, on board. Subsequently, the naval dietary was reformed, with the magnificent result that during 1885 to 1889 the ratio of beri-beri fell to 0.59, 0.04, 0.00, 0.00, 0.03. Such are, relatively and absolutely, the ways and the practical effects of scientific procedure.²

¹ As a matter of fact, the reasoning was at least partly incorrect. The "polished" rice consumed by the sailors lacked the anti-neuritic factor removed in the milling process, and this was rectified by increasing the quantity of other eatables containing a sufficiency of that factor. (See on the whole question, *Report on . . . Accessory Food Factors*, London, 1919.)

² The above account relative to beri-beri is taken from Surgeon-Major L. L. Seaman's valuable work *The Real Triumph of Japan*, New York, 1908. The prevalence of scurvy on British vessels before 1795 offers a precisely parallel picture to beri-beri. Its ravages used to be appalling; but since the introduction of lemon juice or a corrected dietary, the disease is practically unknown. It is to be hoped that equally efficacious cures for consumption, cancer, and children's infectious diseases may be discovered, although these afflictions belong to a different category. In reference to scurvy, Herschel (*Discourse*) states: "So tremendous were the ravages of scurvy, that, in the year 1726, Admiral Hosier sailed with seven ships of the line to the West Indies, and buried his ships' companies twice, and died himself in consequence of a broken heart." ([44].)

§ 59. The plain man has been for ages occupied in wealth production, and might be supposed to be a pastmaster in this art. Yet the efficiency movement, inspired by science, puts to shame his efforts in this domain. Here are some illustrations. "We cite as an example a case of folding handkerchiefs. The old method of folding was to have the worker seated at low tables in chairs of ordinary height, working throughout the entire day, with the only rest periods an hour at noon and such ceasing from folding as took place when the workers went for supplies, or took back finished product to be checked, or other rest periods that they took at will, as the work was piece work. After an intensive study of the problem, made not only to increase their output but to better their working conditions and allow them to earn more money with less fatigue, the following schedule of work and rest periods was adopted. Each hour was divided into ten periods. The work was placed on a work table of the proper height. The handkerchiefs already folded, those being folded, and those to be folded were arranged in the most convenient and efficient manner. All variables of the work had been studied, and the results of the study standardised. The first four periods, that is, the first twenty-four minutes, the girl remained seated. She worked five minutes and rested one; again worked five minutes and rested one. That is to say, she had four minutes' rest out of the twenty-four, and spent this rest seated so that she might lose no time in getting back to the work. The next two periods, that is for twelve minutes, the girl was standing. Again she worked five minutes and rested one minute, and for the second time worked five minutes and rested one minute. That is, she rested two out of the twelve minutes in the same position in which she worked. The third group, a space of eighteen minutes, she spent either sitting or standing, as she pleased. Here also she worked five minutes, rested one minute; worked five minutes, rested one minute; worked five minutes, and rested one minute in the position, either standing or sitting, which she herself had chosen. The last period, which consisted also of six minutes, was spent by the girl walking about and talking, or amusing herself as she otherwise chose. With this might be combined the last rest minute or period number nine, which thus gave her seven consecutive minutes for unrestricted rest activity. This was the schedule for all hours of the day except the hour before noon and the hour before closing time at night. In these hours the first nine periods resembled the first nine periods of the other hours; but the tenth period was spent in work, as a long rest period was to follow. At the end of the day's work under these conditions the girls accomplished more than three times the amount of their previous best work, with a greater amount of interest and with no more fatigue." (F. B. and L. M. Gilbreth, *Fatigue Study*, 1919, pp. 127-129.)

Overhauling and cleaning a boiler may seem a matter in which science has no suggestions to offer. The founder of the efficiency movement manifestly thought otherwise. "Time study showed that a great part of the time was lost owing to the strained position of the workman. Thick pads were made to fasten to the elbows, knees, and hips; special tools and appliances were made for the various details of the work; a complete list of the tools and implements was entered on the instruction card, each tool being stamped with its own number for identification, and all were issued from the tool room in a tool box so as to keep them together and save time. A separate piece work price was fixed for each of the elements of the job, and a thorough inspection of each part of the work secured as it was completed. The instruction card for this work filled several typewritten pages, and described in detail the order in which the operations should be done and the exact details of each man's work, with the number of each tool required, piece work prices, etc. The whole scheme was much laughed at when it first went into use, but the trouble taken was fully justified, for the work was better done than ever before, and it cost only eleven dollars to completely overhaul a set of 300 h. p. boilers by this method, while the average cost of doing the same work on day work without an instruction card was sixty-two dollars." (F. W. Taylor, *Shop Management*, 1919, pp. 181-182.)

It is no wonder, then, that those conversant with the scientific movement in industry hail it as the great liberator from witless routine. "'I cannot prophesy the end, there is no end. I am learning my trades all over again', testified a prominent contractor in regard to the system, before the Interstate Commerce Commission. Scientific management is said to differ from the ordinary systems of production 'much as production by machinery differs from production by hand; and the revolution which must result from the introduction of scientific management, is comparable only to that involved in the transition from hand to machine production'." (Josephine Goldmark, *Fatigue and Efficiency*, 1912, pp. 192-193.) Untutored common sense is thus being expelled from its last stronghold.

Macaulay was right in denying to Bacon the claim for complete originality; but this claim the great Elizabethan methodologist never advanced. What Bacon resolutely combated was the common practice of reasoning from propositions to propositions heedless of examining the data and verifying the results. He would have expressed, for instance, nothing but condemnation, we fear, for so brilliant a thinker as Herbert Spencer who first issued an elaborate Syllabus, and then spent forty years in filling in its outlines. It would be hard to refute Bacon's reasoning in favour of a methodology: "If in things mechanical men had set to work with their naked hands,

without help or force of instruments, just as in things intellectual they have set to work with little else than the naked forces of the understanding, very small would the matters have been which, even with their best efforts applied in conjunction, they could have attempted or accomplished." (Preface to *Novum Organum*.)

SECTION XVIII.—CONCLUSION.

§ 60. The foregoing discussion has no pretensions to being exhaustive; it only strives to clarify a few of the principal terms employed in scientific methodology. The signification of Concept, Abstraction, Comparison, Judgment, and of a multitude of other logical terms, will be found dealt with in the works of classical and inductive logicians. The methodological aspect of the memory, the imagination, and the intelligence is treated in Conclusion 18, and that of the methodological process as a synthetic unity, in Conclusion 2. Our limited purpose in this Second Part has been achieved if we have thrown some light on certain vital terms, terms which we hope will receive in the future closer attention from logicians. Our discussion at the same time has made it manifest, we hope, that in sundry departments of knowledge methodological canons are honoured in the breach rather than in the observance, even in respect of such elementary matters as adequate preliminary observation and detailed verification.

We may now proceed to the consideration of the proposed methods of thought which, we trust, fairly reflect on the whole the process of modern scientific investigation at its best.

BOOK II.
PRACTICE.

PART III.

INTRODUCTORY.¹

SECTION XIX.—INTRODUCTORY AND SUMMARY.

I.—INTRODUCTORY.

§ 61. Bacon characterises the scientific thinker by attributing to him largeness of capacity, faithfulness of memory, swiftness of apprehension, and penetration of judgment.² (*Advancement of Learning*, Dedication, second paragraph.)

Having perhaps this passage dimly in mind, Descartes expresses himself in this form: "Pour moi, je n'ai jamais présumé que mon esprit fût en rien plus parfait que ceux du commun: même j'ai souvent souhaité d'avoir la pensée aussi prompte, ou

¹ It would be a grave and unpardonable error to suppose that every invention and discovery of note dates from the rise of modern science; for before that era man had invented language, alphabets, the arithmetical notation now in use, and customs, manners, morals, religions, and laws; domesticated diverse animals; developed the cereals, vegetables, and fruits, and discovered the use and safe production of fire; extracted, utilised, and mixed various metals; introduced the axe, the knife, the saw, the plough, the wheel, glass, mirror, sails, bricks, windmill and watermill, the calendar, the compass, spectacles, clocks, and scores of other inventions and discoveries of far-reaching significance; built magnificent roads, waterways, carriages, ships, and temples; produced unsurpassed works of art, and developed man's sense of the beautiful; and laid the foundations of mathematics, astronomy, logic, and medicine, besides those of poetry, the drama, and literature generally. In these circumstances, whilst determined to mete out ample justice to modern science, it behoves us to speak with profound appreciation of what men accomplished in the far past. According to Alfred Russell Wallace the nineteenth century is responsible for the subjoined first-class inventions—railways, steam-navigation, electric telegraphs, the telephone, friction matches, gas lighting, photography, the phonograph, Röntgen rays, spectrum analysis, the use of anæsthetics, and the employment of antiseptics—a truly wonderful output for *one* century.

² Here is a more comprehensive Baconian summary: "For myself I found that I was fitted for nothing so well as for the study of Truth; as having a mind nimble and versatile enough to catch the resemblance of things (which is the chief point), and at the same time steady enough to fix and distinguish their subtler differences; as being gifted by nature with desire to seek, patience to doubt, fondness to meditate, slowness to assert, readiness to reconsider, carefulness to dispose and set in order; and as being a man that neither affects what is new nor admires what is old, and that hates every kind of imposture." (*De Interpretatione Naturæ Proœmium*, Spedding's translation)

l'imagination aussi nette et distincte, ou la mémoire aussi ample ou aussi présente, que quelques autres. Et je ne sache point de qualités que celles-ci qui servent à la perfection de l'esprit." (*Discours de la méthode*, 1668, second paragraph.)

Kant says: "Two things chiefly are required in a philosopher—1. Cultivation of talents and skill, so as to use them for various ends. 2. Readiness in the use of all means to any ends that may be chosen. Both must be united." (*Introduction to Logic*, London, 1895, p. 16.)

Charles Darwin expressed himself thus: "I think I am superior to the common run of men in noticing things which easily escape attention, and in observing them carefully. From my earliest youth I have had the strongest desire to understand or explain everything I observed—that is, to group all facts under some general laws." (Frank Cramer, *op. cit.*, p. 29.)

Bain particularises: "To possess the mind of a large store of the related facts; often to refresh the recollection of them; to come into frequent contact with objects that seem likely to afford comparisons and analogies; not to stand too near at one set of facts so as to be overpowered by their specialities; not to be engrossed with the work of observing the facts; and, in general, as of matters of great difficulty, to keep the mind free from attitudes and pursuits antagonistic to the end in view." (*Logic*, vol. 2, p. 415.)

La logique, ou l'art de penser, 1662, contains a section entitled "La méthode des sciences réduite à huit règles principales".

Spinoza formulated the following rules for the conduct of the understanding: "(1) There is the knowledge which we derive from hearing or from some arbitrary sign. (2) There is the knowledge which we derive from vague experience. . . . (3) There is the knowledge which arises when the essence of a thing is deduced from another thing, but not adequately. . . . (4) Finally, there is the knowledge which arises when a thing is perceived through its essence alone, or through the knowledge of its proximate cause." (*Tractatus de Intellectus Emendatione*, London, 1895, pp. 9-10.)

Leibniz submits the following rules referring to the art of invention: "(1) To know a thing, one must take into account all the requisites ('requisits') of the thing, that is, everything necessary to distinguish it from everything else. This we may name definition, nature, reciprocal property. (2) Apply the rule to each condition, or requisite, that enters into the definition which has been found, and look for the requisite of each requisite. (3) When the analysis has been pushed to the end, the perfect knowledge of the thing proposed has been reached." (Couturat, *La logique de Leibnitz*, p. 181.)

Kant has sundry allusions to practical scientific rules. According to him, "Logic is not a general art of discovery nor an organon of truth; it is not an algebra by help of which hidden truths may be discovered". (*Introduction to Logic*, 1895, p. 10.) He claims that the "general rules and conditions of the avoidance of error are (1) to think oneself; (2) to put oneself in thought in the place or point of view of another; and (3) always to think consistently. The first may be called enlightened; the second enlarged; and the third consequent or coherent thinking". (*Ibid.*, p. 48.) Kant furnishes eight further practical rules (pp. 33-34) which, for want of space, we cannot quote.

Auguste Comte proposes the hereunder mentioned fifteen universal principles or laws: "Law 1. Form the simplest and most sympathetic hypothesis consistent with the whole of the known facts.—Law 2. Regard as invariable all laws whatsoever which govern phenomena and, through them, beings.—Law 3. All modifications of the universal order are limited to the degree of intensity of the phenomena, their arrangement not admitting of alteration.—Law 4. All subjective constructions are dependent on objective materials.—Law 5. The internal images are always less vivid and less distinct than the external impressions.—Law 6. The image which is our immediate object must predominate over all that are simultaneously evoked by the excitement of the brain.—Law 7. Every understanding passes through a succession of three states: fictitious, abstract, and positive, in all its conceptions without exception, with a velocity proportioned to the generality of the phenomena in question.—Law 8. Man's activity passes through a succession of three states: Conquest; Defence; and, lastly, Industry.—Law 9. Man's social existence has also a succession of three states: the Family, the State, Humanity. It is domestic, civic, universal, in accordance with the peculiar nature of each of the three instincts of sympathy.—Law 10. Every condition, statical or dynamical, has an inherent tendency to continue as it is without change, resisting all disturbance from without. (Kepler.)—Law 11. Every system maintains its constitution, whether in exercise or at rest, when its constituent parts are subjected to simultaneous changes, provided that the changes affect all the parts in equal degree. (Galileo.)—Law 12. Reaction and action are always equivalent, if the degree of each is measured in accordance with the peculiar nature of each collision. (Newton.)—Law 13. The theory of motion must be subordinated to that of existence, by looking on all progress as the development of the particular order in question, the conditions of such order, whatever they may be, regulating the changes which together make up the evolution.—Law 14. Every positive classification must proceed on the principle of the increase or decrease of generality, whether subjective or objective.—Law 15. The intermediate state should be in all cases subordinated to the extremes which it brings into connection." (Richard Congreve, *Positivist Tables*, London, 1892, pp. 26-28.)

Huxley epitomises in this manner the method of science: "The methods [of the sciences] are all identical: 1. Observation of facts, including under this head that artificial observation which is called experiment. 2. That process of tying up similar facts into bundles, ticketed and ready for use, which is called comparison and classification; the results of the process, the ticketed bundles, being named general propositions. 3. Deduction, which takes us from the general proposition to facts again, teaches us, if I may so say, to anticipate from the ticket what is inside the bundle. And, finally, 4. Verification which is the process of ascertaining whether, in point of fact, our anticipation is a correct one." (*Twelve Lectures and Essays*, ed. 1915, p. 12.)

Here is a philosophical summary of the nature of the scientific process: "The aim of the scientific process as it occurs in the individual is to render the Objective in its actual determinations intelligible. This happens when primary facts enter into an 'apperceptive system'. . . . If the process has been of the kind intended by the term scientific, it will have the further property of leading to other determinations of the Objective, and these further determinations are the actual achievements of science, and its 'end', therefore, from the universal point of view." (T. Percy Nunn, *The Aim and Achievements of the Scientific Method*, 1907, pp. 142-143.)

An expert thinker, it might also be suggested, will perennially and intently concentrate his mental powers in order that he might, with the aid of appropriate canons, rapidly discover, record, verify, connect, preserve, and communicate static and

dynamic facts, and expeditiously and discriminatingly extend and apply them to all related cases, near and remote, self-revealed and obscure, his interest being centred in one or a very few problems. Or we may vary this by stating that the end of an enquiry should be (a) one or a moderate number of tolerably original, comprehensive, and important conclusions, including theoretical and practical applications possessing the same character; and (b) to determine precisely the nature and relations of certain facts. With regard to the form which an enquiry should assume, it ought to be as sharply defined as possible, continuous, and fairly limited in scope. Everybody is aware of what is signified by the enquiry being sharply defined. By its being continuous, we mean that the ground of the enquiry shall not shift unless the enquiry itself imperatively demands it; and by its being fairly limited we imply that the range of the enquiry shall neither extend, as with the ancients, to the embracing of all or most knowledge as one's province, nor to be too restricted as in many modern monographs, for in the former instance we obtain nebulous, in the latter petty, generalisations.

*The object of a scientific methodology is to determine the most efficient modes of conducting the operations of the human understanding.*¹ In the widest sense, therefore, a scientific methodology relates to thinking in general, and, consequently, to daily life as well as to methodical enquiries. Or, stated formally and more ambitiously, a scientific methodology aspires to transform men and women into as nearly as possible ideal thinkers. Accordingly, the most effective means of collecting, storing, teaching, and otherwise disseminating, truth are also part of its province. For this reason, a coherent system of methodology should concern itself as much with generalisation as with deduction, with theory as with practice, with certainty as with probability, and with single events as with classes of these. Different departments of methodology hence exist, treating respectively of the discovery, the application, the preservation, the teaching in educational establishments, and the communication by other means, of truth. *In this treatise, however, we are chiefly*² *concerned with the methods leading to the discovery of scientific truths.*

¹ "The general problem of methodology is to show how we may apply our natural mental activities, in such a way that starting from a given state of thought and knowledge, we may attain the object of human thought by an ideally perfect process; a process, that is, in which none but fully determined concepts and adequately grounded judgments are employed." (Sigwart, *Logic*, vol. 2, p. 3.) And Wundt (*Logik*, vol. 1, p. 1) writes: "Die Logik hat Rechenschaft zu geben von denjenigen Gesetzen des Denkens, die bei der wissenschaftlichen Erkenntnis wirksam sind." It is also true that "every science develops its characteristic methods, methods fruitful in their results, which it employs in dealing with a given class of problems". (Lotze, *Logic*, vol. 2, p. 174.)

² Incidentally the problem of general efficiency is somewhat exhaustively treated in this work. See Index, and especially Conclusion 10.

Having stated the most general precepts pertaining to scientific investigation, we may, before proceeding to the detailed statement which is the primary object of this volume, focus the various synthetically connected main injunctions in the sentence: "Examine minutely and circumspectly under the most varied circumstances of space, time, and other conditions, and experiment where practicable; generalise step by step, but yet, within reason, exhaustively; proceed, more especially towards the end, to deduce further truths issuing perhaps in fresh investigations; verify all observations, generalisations, and deductions meticulously, and determine their theoretical and practical applications; judiciously classify the facts as you proceed, but especially during the last stages; and luminously summarise the theoretical and practical results in concise, definite, connected, and comprehensive interim and final formulæ." Bacon's conception of method is also synthetic in character, and may be paraphrased thus to satisfy, more or less, modern requirements: "Collect all the classes of facts and their degrees bearing on the enquiry; collect classes of facts similar to those found but which do not bear on the enquiry, and exclude those and their similars; seek, by the method of exclusion, for the facts common to all the relevant classes of facts; precipitate the truths common to the facts into a definition; proceed to draw theoretical and practical deductions; classify the facts; verify throughout at every step; and formulate a pithy and yet exhaustive statement relating to the enquiry." In Bacon's conception of method hypotheses play only an important part at certain turning points.

II.—SUMMARY OF PRACTICAL CONCLUSIONS.

§ 62. Human advance along every line has been due to the gradual accumulation pan-humanly—that is, inter-individually, inter-socially, and inter-epochally—of slight improvements, and our sciences, arts, industries, and disciplines, have all grown in this inconspicuous but effective way. The difference between a high and a low stage of civilisation is accounted for in this manner, and it is extremely probable that in any direction where there has not been an advance thus determined, we have tarried on a low level. The method of conducting the human understanding, as we perceived in Section V, falls under the same law, and its degree of evolution we can fairly judge by gauging the history of methodology. This latter evidences that apart from collectively determined progress in logic, summed up in Aristotle, and, more especially, in Francis Bacon, little that is fundamental has been done to establish a recognised methodology.

Whatever substantial progress has been effected since Bacon wrote is mainly to be attributed to the advance of the sciences themselves, and the full methodological significance of this ad-

vance remains yet to be systematically recorded, if we abstract the incomplete work accomplished in this treatise. Accordingly Dame Fortune still decides as a rule what the method pursued by any person shall be. That is, the outcome of an enquiry may be a rambling essay, without commencement, middle, or end. It may represent a mere formal treatment of a subject, regardless of the facts of the case. It may be a deductive statement, starting from some monstrous assumption, or from a legitimate hypothesis. It may deal with a fraction of a subject or with the Universe itself. It may be determined almost entirely by preconceptions, or maintain a hoary thesis of the schools. In reality, the unaided intelligence is prone to disregard everything but plausible coherence in argument and an enumeration of a few affirmative instances of a more or less specious character, whilst it tends to be sublimely unconscious of methodical and cautious observation, measurement, use of instruments, experiment, generalisation, deduction, verification, definition, and whatever else a methodology of science postulates.

In these circumstances we can only expect what we find—a countless host of lectures and publications, a clashing of opinions, a war of words, a struggle to make antagonistic theories triumph, with glimpses of the truth discernible here and there. Judging by what man is able to compass in any department of life without helps, being kept back by “the mist of tradition, or the whirl and eddy of argument, or the fluctuations and mazes of chance and of vague and ill-digested experience”,¹ it is incumbent on us to consider as natural this slow and tortuous progress in knowledge. An ideal methodology would guide the man of science from the inauguration to the termination of his enquiry, and render it almost impossible for him to go far astray. (See especially Conclusions 2, 5, 17, 19, 27, and 28.) At such a consummation the methodologist must aim; but since even moderate perfection is the leisurely product of the ages, he can only offer a work which shall form a stepping-stone towards a growingly more accurate and complete methodology. Yet the ideal should never be lost sight of by him, if only because it will spur him on to essay his best, and because it will convince him that even his best is something destined to be far, far excelled. It is in this chastened mood that the series of Conclusions which follow have been formulated, and it is with the intention of supplying a bird’s-eye view of these Conclusions that a summary of them is herewith subjoined.

I.—GENERAL SUMMARY.

§ 63. (A) *Preparatory Stage.* (a) We commence our enquiry by establishing the need of methodological procedure. (Conclusion 1.) (b) We show the desirability, the nature, and the

¹ Bacon, *Novum Organum*, bk. 1, 82.

origin of a synthetic methodology. (Conclusion 2.) (c) We determine the special and general object of our enquiry. (Conclusions 3-4.) (d) We seek to do justice to certain other preliminary considerations, including provision for experimental methodological training. (Conclusions 5-12.) (e) We furnish typical examples of the suggested mode of procedure. (Conclusion 13.)

(B) *Working Stage.* (a) We commence by contemplating the precise nature of the problem to be investigated. (Conclusions 14-15.) (b) We examine the facts in question according to certain methods. (Conclusions 16-24.) (c) Having exhaustively observed, we methodically generalise. (Conclusions 25-28.) (d) We verify facts and statements. (Conclusion 29.) (e) We formulate an interim statement. (Conclusion 30.) (f) We proceed to theoretical and practical deductions. (Conclusions 31-32.) (g) We classify the material facts elicited by the enquiry. (Conclusion 33.) (h) We frame our final statement. (Conclusion 34.) (i) We prepare a report for reference or for publication. (Conclusion 35.)

(C) *Final Stage.* We consider the wider application and the improvement of the series of Conclusions. (Conclusion 36.)

II.—SPECIAL SUMMARY.

§ 64. (1) There is a pressing need of procedure being determined methodologically. (Conclusion 1.) (2) There is an equal need that the methodology shall possess a synthetic character. (Conclusion 2.) (3) The special object of any enquiry is to determine the general nature and relations of certain phenomena, and to promote this end we frame tables of categories. (Conclusion 3.) (4) The general object of an enquiry is to reach one or a few correct and comprehensive conclusions. (Conclusion 4.) (5) Before beginning an investigation, we should discover a practicable starting point, and acquire some notion in respect of the complexity of the task which we can profitably undertake. (Conclusion 5.) (6) We must next be resolved to shun vagueness and over-subtlety (Conclusion 6); (7) beware of trusting to formal rules or allowing ourselves to be influenced by any kind of bias (Conclusion 7); and (8) take advantage of special scientific methods besides utilising existing knowledge, whilst allowing for the personal equation and for training. (Conclusion 8.) (9) We recognise the need for experimentally preparing ourselves for efficient investigation (Conclusion 9), (10) and for securing the mental, physiological, and environmental conditions conducive to efficiency. (Conclusion 10.) (11) Not having at our disposal unlimited time to observe everything, we systematically skip over battalions of facts and methodically jump to a provisional conclusion, *i.e.*, we frame hypotheses, never jumping, however, unless we are tolerably assured of the result

through an extensive preliminary investigation. (Conclusion 11.) (12) We can accomplish practically nothing of consequence by ourselves, and therefore the widest collaboration is necessary in scientific work. (Conclusion 12.) (13) We familiarise ourselves through a few examples with the form an enquiry should take. (Conclusion 13.) (14) We seek to determine the precise nature of the problem to be investigated. (Conclusion 14.) (15) Common experience resembles shifting sands, and common terms and reflections mirror them. Accordingly, in seeking to determine the precise nature of the problem, we need to aim throughout the enquiry at rigidly defined terms, at precise comprehensive conclusions, and at definiteness in thought and statements generally. (Conclusion 15.) (16) We look around for undisputed facts apposite to our enquiry, and note what patent resemblances and divergences they present. We turn in every direction in space and time to collect samples of the phenomenon until we are reasonably sure that we fairly apprehend its specific nature. In observing, there is need of strenuous mental application, and need of the observations being, among other things, graded, comprehensive, important, numerous, full, rational and relevant, original, automatically initiated, and methodically developed. (Conclusion 16.) (17) We take now a snapshot at a particular fact. We examine whether it is really one and not composite, really composite and not one. We distinguish it from its environment, and measure the influence of time and position in space and consciousness. (Conclusion 17.) (18) To observe, even for an instant, is mainly to recognise; to observe for several instants involves that we do not forget what we observe from instant to instant; and the conduct of an enquiry therefore commonly implies an efficient memory and keeping and consulting records. Furthermore, the process entails adaptation to circumstances known and unknown, and therefore a more or less full use and understanding of the imagination and a systematic utilisation of the thought process. (Conclusion 18.) (19) We acknowledge the need for ensuring easy, exhaustive, and impartial observation. (Conclusion 19.) (20) We search for the simplest practicable case. (Conclusion 20.) (21) We are habitually alert, and keep our attention unremittingly concentrated. (Conclusion 21.) (22) We collect the largest number of facts accessible to an indefatigable investigator, and ascertain the unlike as well as the like. (Conclusion 22.) (23) We exhaust classes of static and dynamic facts, their conditions, and their accompanying uniformities. (Conclusion 23.) (24) Our attitude is throughout critical and our treatment provisional, and we test results repeatedly. (Conclusion 24.) (25) Having observed a number of instances, we collate the common characters, and form one or more generalisations. In generalising, there is need of strenuous mental application, and need of the generalisations being graded, comprehensive, important, numerous, full,

rational and relevant, original, automatically initiated, and methodically developed. (Conclusion 25.) (26) We also remember to postpone indulging in large generalisations until near the conclusion of the investigation. (Conclusion 26.) (27) We exhaust the degree of applicability of a conclusion, and also strive to discover parallel, distantly related, and seemingly unrelated, instances. (Conclusion 27.) (28) We proceed dialectically, and search for what is contradictory, contrary, opposite, common, disparate, supplementary, alternative, complementary, dependent, interdependent, and relative. (Conclusion 28.) (29) We should be on our guard against error, and therefore need to verify what we deem that we have already ascertained. Moreover, generalisations and deductions being admittedly hypothetical, verification and demonstration are essential if they are not to prove broken reeds. Indeed, verification must needs be resorted to at every stage of the enquiry. (Conclusion 29.) (30) After having exhausted and gradually consolidated the various lines of the inductive enquiry, we aim at a balanced interim statement which is also to serve as a basis for the fuller deductive process. (Conclusion 30.) (31) The moment we possess statements which are at all reliable, we endeavour not only to extend them, but we see whether we can deduce anything from them. There is need of strenuous mental application in the process of deduction, and need of the deductions being graded, comprehensive, important, full, rational and relevant, original, automatically initiated, and methodically developed. (Conclusion 31.) (32) We complete the deductive enquiry by drawing whatever practical deductions the circumstances permit. (Conclusion 32.) (33) We also recognise the necessity, more especially in the last stages of an enquiry, of judiciously classifying facts. (Conclusion 33.) (34) We formulate a comprehensive final statement. (Conclusion 34.) (35) We acknowledge the need of being concise in statements, of circumspectly summing up, and of writing acceptably. (Conclusion 35.) (36) And, finally, we recognise formally the need of respecting each of the above Conclusions in all the above Conclusions, of improving these, and of applying them systematically to the life of practice. (Conclusion 36.)

§ 65. If, in imagination, we place ourselves in the hoped-for future when practically all men and women will be models as regards scientific thought, and when language itself will be a scientifically fashioned instrument, we shall find the adage "*non multa, sed multum*" exemplified there. Such will be the effectiveness of thought and the treasure of accurate and systematised information absorbed by each that, on an investigator publishing merely the full definition or generalisation he has arrived at, those interested will be mostly able to infer not a little that is of moment with ease and promptitude. Conversely, the investigator himself will be so perfect a methodologist—aided by classifications, notations, tables, diagrams, machines, etc.—that,

apart from the process of collecting obscure facts, his work, at least compared to that of a modern investigator, will be almost like child's play. (See § 114.) Indeed, all men and women will be inventors and discoverers of an elevated order, and comparatively little of secondary importance will need to be imparted or learnt. The conception of the real and the possible in this connection should act as a potent incentive to those who desire to liberate mankind from groping ignorance and servile dependence on chaotic traditions.

PART IV. PREPARATORY STAGE.

SECTION XX.—STUDIES PREPARATORY TO ALL INVESTIGATIONS.

CONCLUSION 1.

Need of Procedure being determined Methodologically.

§ 66. The assumption underlying all methodological thinking is that we should be conscious of the need of proceeding methodologically. At present such consciousness can scarcely be alleged to exist. Method to-day is mostly a matter of tradition, and fortunate are those sciences where the traditions are of a superior order.

In many of the social sciences, for instance, scientific method is almost completely ignored. The writer on ethics, for example, is as a rule unperturbed either in regard to making sure of his facts or as to verifying his conclusions, unless indeed fugitive and haphazard attention to these is to be honoured by such a name. He generalises, he deduces, he speculates, he affirms and denies, irrespective of a stern and synthetic guiding rule. No wonder, therefore, that ethical systems are almost as plentiful as blackberry bushes in the country. Any one with an exuberant imagination, well read in general, who has acquainted himself with the airy speculations of the past, can possess his own ethical universe of thought.

If we turn to psychology, we are on a relatively higher plane, since much is made here of facts; but rigorous method is also in this instance deplorably lacking, witness the almost universal acceptance of commonplaces—which are the bane of science—relating to the nature of the sensations, attention, habit, memory, imagination, ratiocination, pleasure and pain, emotions, will, and touching almost everything else in psychology. No wonder that Herbart, Thomas Brown, and James Mill, who wrote about a century ago, are scarcely out of date, except perhaps for part of their plain terminology.

In sociology abundant and invaluable detail work has been performed; but if we reflect that one may almost say "as many sociologists, so many sociological systems", one feels that here also too much freedom is given to the speculative fancy.

In short, over extensive tracts of modern thought, no true scientific spirit broods. Unjustified generalisations and deductions abound, methodical observation and verification are neglected, subtlety in argument is prized, traditions, conventions, and prejudices are revered, affirmative instances are assiduously collected and negative instances disposed of by ingenious arguments, and were it not that our well-informed age has collected many facts exacting a minimum of allusions to reality, we could not be said in diverse departments to be far removed from pre-Baconian days.

The first need, then, is to be aware that most generally men's cogitations are not methodologically controlled, and that scientific advance would be immensely aided if the reverse were the case. Unmethodological thinking is world-removed from methodological thinking. Let us submit some examples in illustration of this contention. (See also Section IX.)

§ 67. In recent years the theory has become increasingly popular that the human species, like animal species, is primarily determined in its conduct by instincts, *pace* the works of Kirkpatrick, McDougall, Ellwood, and others. At last we are supposed to have struck the bedrock fact in psychology, sociology, and ethics. Yet extreme vagueness is noticeable regarding the signification of the term Instinct. Sometimes it is conceived as an impulse; sometimes as an inherited functional arrangement by which impulses are gratified; sometimes it is confounded with the total hereditary outfit; and its distant relation to automatic and reflex action, on the one hand, and habit and deliberate thought, on the other, is confidently commented on. That is, a popular conception, misty in the highest degree, is proposed as the basis of a number of sciences.

As a matter of fact, several factors are involved in the term Instinct and should be made explicit. The existence of native impulses or (a) *inborn needs* should be considered as forming a separate fact. A child who is kept inordinately long without food may become unhappy and complain of a pain somewhere in the neighbourhood of the stomach. There is here a disequilibrium, but without any connected tendency to right itself. Should such an equilibrating tendency be inborn, we frequently speak of an innately determined mode of procedure or (b) *instinct*. But if instincts are dependent on needs, they are no less dependent on (c) *organs* whereby to satisfy the needs. These organs, again, are often of a specific character, as the tiger's claws, the mole's snout, or the spider's spinning apparatus. Beyond needs, modes of procedure, and means, we should also allow for (d) the *general adaptive structure of*

the animal, as in the suppleness of the cat, of (e) *certain protective structures* like the tortoise's armour, and for the so-called (f) *automatic* and (g) *reflex acts* which determine certain bodily actions, internal and external. Only when the problem is conceived in this many-sided way by allowing for at least seven distinct inborn factors, is it probable that we shall not be ensnared in a net of words when comparing, for example, human and animal "instincts". Methodologically it is inconceivable that a world-wide movement, inspired by scholars of distinction, should have existed for a number of years favouring the instinct theory, and that yet the theory should remain in a shockingly rudimentary state.

The kindred problem of heredity and culture is in the same predicament. Scores of works, dealing directly or indirectly with heredity, assert emphatically that just as the activities of animals are determined primarily by congenital capacities, so are those of human beings. In whatever walk of life therefore men or women are superior to their fellows, they have, it is contended, to ascribe their superiority mainly to their native outfit. Education has assigned to it a certain value, but a quite subsidiary one. Yet methodologically this constitutes again an impossible attitude. Why not learn what primitive peoples can and do achieve at school and at college—economic, scholastic, and other surrounding conditions being approximately equal?¹ Why not observe cases of the adoption of new-born infants where family circumstances have been radically altered? Or, as a matter of fact, why not pursue the recognised experimental method, adopting children of different peoples and social layers from birth, and giving each as nearly as possible the very same and the very best education and upbringing? Why not? Because our age is as yet mostly unconscious of the need of procedure being determined methodologically, and is too frequently content to pronounce magisterially on matters for which it has no verified evidence.

Similarly with the cognate case of the historical advance of culture. Here, from Darwin onwards, it has been ceaselessly reiterated that the changes in species are too slow to be directly observable. Nevertheless, Darwin and his followers have alleged the existence of a chain of traceable biologically-produced transformations in man, from the Australian aboriginal (whose mentality and morality were supposed to be scarcely higher than those of the apes) to the advanced European (said to be capable of acute logical penetration and limitless altruism). Methodological reflection would have forced the contradiction into the foreground and would have shown that if natural selection has produced the cultural differences between Australian and Central European, it necessarily follows that about equally great

¹ E. B. Sargant, *Report on Native Education in South Africa*, Part III, 1908.

differences should be visible in at least many of the higher animal species, which is decidedly not the fact, as Darwinians themselves are at pains to demonstrate.

§ 68. Again. Scrutinise in this light Herbert Spencer's thesis that "every kind of progress is from the homogeneous to the heterogeneous". This interesting assumption he strives to substantiate by adducing a liberal number of pertinent illustrations in his essay "Progress: its Law and Cause".¹ Had methodology been a recognised science in his day, he could never have proceeded as he did. He would have automatically tested his assumption by searching, as Darwin would have done, for instances where the opposite tendency, that towards homogeneity, was expressive of progress, and generally applied dialectical methods such as those incorporated in Conclusions 27 and 28. With but a modicum of labour he would have accordingly reached the conclusion that his plausible thesis was untenable and should be abandoned. For example. In our generation integration has been a signal method of progress. Speaking generally, the variety of meridians has been reduced to one; a single gauge, in the place of the pre-existing multitude of gauges, has been growingly favoured for railway tracks, and a single universal keyboard for typewriters; screws and numerous other industrial products have been standardised;² the metric system has superseded the many local standards of measurement in diverse countries, and bids fair to be universally adopted; the standardising of Census and other statistics has been suggested and partly realised;³ the rules of the sea and those of warfare are each being gradually reduced to a single system of rules; processes and methods of organisation are coming to be standardised in industry and commerce generally; nations enter into compacts whereby numberless differences bearing on international relations are abrogated and replaced by uniform practices; scientific bodies are intermittently engaged in elaborating international usages pertaining to their special domain and also in coordinating endeavours; the multiplicity of theories which erstwhile obtained is, in one department after another, driven out of the field by a single one or a modest few; comprehensive and unequivocal codes of law

¹ *Essays*, London, ed. 1907.

² "The American Society of Automobile Engineers, finding that 1,100 sizes of seamless steel tubes were being made, prevailed upon the manufacturers to reduce the number to 160; again, finding that 600 sorts of lockwashers were in use, they similarly reduced the number to 20." (M. and A. D. McKillop, *Efficiency Methods*, 1917, pp. 60-61.) "A Government department finds by classifying that 76 kinds of pennibs are used by its clerks; direct economy and the simplification of storage follow by reducing these kinds to seven or eight, with little or no inconvenience to anybody. A printing plant finds, by classifying, that it has stocked 200 types of paper, whereas 85 will cover all possible needs." (*Ibid.*, p. 64.)

³ Patrick Geddes, *The Classification of Statistics and its Results*, Edinburgh, 1881.

take the place of a bewildering mass of dubious precedents; the chaos in administration, both private and public, is progressively being removed; and general advance entails the ultimate abolition of individual and collective error, inequality, and discord. An interminable aggregation of general facts could be thus collected to illustrate that the tendency towards homogeneity comports with the tendency towards progress. Applying other rules comprised in Conclusions 27 and 28, we should learn by degrees that progress is compatible both with increase and decrease of heterogeneity, and that retrogression may be equally accompanied by an augmentation or diminution of differentiation. It would hence become manifest that the law of progress does not lie in the direction surmised by Herbert Spencer. Utilising subsequently other methodological rules, but of a constructive character, the true law and cause of progress would be partly or wholly revealed. Indeed, the universal acceptance of a single and reliable system of methodology, displacing the present blind groping, would of itself denote an epoch-marking stage in human progress.

§ 69. Or consider a quite modern instance of precipitate reasoning. Prof. Siegmund Freud, of Vienna, has developed a theory, the substance of which is that sex is the predominant, or rather the dominant, factor in life.^{1 2} Hysteria and neurasthenia³ are one of its fruits, as well as many forms of insanity⁴, if not all; occurrences of forgetfulness and mistakes in words have mostly the same origin⁵; and dreams⁶ are traced to no other source. A few years have hardly elapsed, and Freudism is threatening to become the fashion. In a sense the theory as developed is complimentary to the moral atmosphere of to-day, for it asserts that we hastily suppress our sex thoughts and prevent them thus from forcing themselves into the strongly illuminated focus of consciousness. However, according to Freud these thoughts revenge themselves by masquerading as ever-recurring innocent thoughts. Then, when the magician of the Freud school is summoned by a patient, he produces a complete and permanent change or cure, by transforming the subconscious feelings and thoughts into conscious ones. Now there is no reason in "the nature of things" as known to us, why this theory should not be true. But is it well grounded? This seems not to be the case. Casual facts are cited in support, a procedure which at best could only prove that such instances occur. On the other side, any normal person who for a month

¹ *Drei Abhandlungen zur Sexualtheorie.*

² In England Freudism flourishes under the name of psycho-analysis and the psychology of the unconscious, and has as a rule discarded the general theory that sex reasons underlie all human abnormalities and defects.

³ *Studien über Hysterie.*

⁴ *Sammlung kleiner Schriften zur Neurosenlehre.*

⁵ *Zur Psychopathologie des Alltagslebens.*

⁶ *Die Traumdeutung.*

has kept a faithful diary of matters or names he forgot, wrong words he used, dreams he experienced, thoughts he suppressed, and who had observed the origination of nervousness, would be probably appalled on how ethereal a foundation a mighty structure can be raised in the absence of methodological thinking. Taking life as a whole, as it passes from moment to moment, and men and women in the mass, at least in certain countries, sex has almost invariably no significant part to play; suppressed and disguised sex thoughts, save at certain junctures, prove to be rare in the waking and dream life of all but the few depraved or diseased;¹ fully conscious ideas often drive individuals into insanity (Lady Macbeth and many in similar positions); and overexertion and economic anxieties, and scores of other causes, lead to nervous instability. A truth applicable to a microscopic part of life, and valuable in itself, is in this way metamorphosed into a gigantic and monstrous falsehood because of lax methodological canons. Here the blame lies less on the originator, whose time and thought are absorbed in endeavouring to detect a new truth, than on the scholarly sympathisers who could readily descry the limitations of the theory, but unjustifiably fail to do this. As a result of this neglect of methodological canons, entire generations are frequently deluded by theories whose truth or error it would be easy to ascertain in a methodological age.

§ 70. Perhaps the acid test of the need of a recognised methodology is the state of logic during the last half century. Let us dispassionately, and without acidity, apply this test. A large number of manuals of logic have been published during this period, mostly entitled *Logic, Deductive and Inductive*. In almost all cases, even where the title was different, the first

¹ Normal mental life is honeycombed with half-suppressed, and especially half-disguised, thoughts of every class. For instance, many individuals are keenly critical of certain defects in others—without noticing that the corresponding defects in themselves induce them to fix their attention on the same defects in their neighbours. Or they may constantly seem to dread being tempted by others, when this is merely due to disguised self-indulgence. Or men, as is so often the case, will find “reasons” for rejecting an unwelcome truth, quite unconscious that aversion to what is unwelcome, and not reverence for truth, is the motive. In a society so complex and so ill organised as ours, half-suppressed and half-disguised thoughts must be of necessity very common in every direction where difficulties are encountered. (See § 82.) Moreover, a thought sharply dismissed has no reverberations, as homely experiments will prove (see also end of § 97), and fixing a thought will equally lead to its definite dismissal. It is only when we half-heartedly turn away from thoughts, or pretend that we dismiss them, or half-coquet with them that they haunt us. However, this is true universally, underlies all sustained cogitations, and according to the life-history of an individual or a people, the type of half-submerged thought may vary indefinitely. Probably local reasons, imperfectly apprehended, suggested to Prof. Freud that sex is the controlling factor of the conscious and sub-conscious life. Living in other regions, intoxicants, worldly ambition, religion, for instance, would have appeared to Freud as constituting men’s inmost desire.

part discussed the Aristotelian logic, and the second part inductive logic.

To the man of science unfamiliar with text-books on logic, but frequently having recourse to deduction in his scientific labours, it would naturally occur to examine the first part of one of those works on logic with a view to finding a detailed exposition of the deductive method. Considering that there is almost a consensus of opinion among logicians in regard to the signal superiority of deduction over induction (§ 49), this scholar would anticipate a forcible and somewhat exhaustive treatment of the subject. He would be therefore amazed when he discovered scarcely a trace of anything directly dealing with, or having a bearing on, what he calls deduction. Anxious to be fair, he would be perplexed at the title of the books and marvel what the Aristotelian logic had to do with deduction. Admirable this logic is in its way, he would argue, but that it is a stranger to the process of deduction in science is patent.

On further reflection he may reason that possibly, however inconsistent it might appear, the problem of deduction is adequately examined in the second part of these works, that is in the part relating to induction. Turning to this, he will probably discover pertinent references, but of the scantiest kind. Leaving aside theoretical discussions of the precise signification of the terms induction and deduction, he will presumably not find half-a-dozen pages allotted to the subject, all save a page or so being devoted to a general survey. Having virtually consulted every recent volume on logic, he will wonder what advantage accrues to young students who master any of these treatises. Certainly, so far as deductive procedure in science is concerned, they could scarcely know less after studying such manuals than they knew before.

Thoroughly aroused, our man of science sets himself the laborious task to learn what these manuals *do* teach. Having completed his enquiry, we may imagine him summing up his conclusions in this manner: "The Aristotelian logic, exhaustively dealt with in the first part of these volumes, has, manifestly, a definitely practical object—to ensure, so far as mere reasoning about matters completely known is concerned, that conclusions should be systematically tested by a certain process. Tacitly or overtly, however, the hoary custom of requiring students to assimilate the Aristotelian logic, has degenerated into a mere memorising and understanding of the text. For sundry dubious reasons, the palpable and justifiable object of the discipline is ignored or disputed. In our scientific age, this logic may go but a little way; but intelligently apprehended, it is worth being acquainted with. What strikes one in this respect, is how alarmingly illogical logicians can be, discussing a plainly practical treatise as if it were a work having not the remotest connection with practice.

"The second part of these manuals is more provoking. This part is supposed to represent modernity and science, as the first part obviously reflects antiquity and verbalism. Broadly speaking, we have here a more or less close reflection of John Stuart Mill's treatment of induction. Proceeding practically on the assumption that discovery is due to innate and unanalysable capacities possessed only by the favoured few, the contention of the authors generally is that inductive logic is only concerned with proof. Even so, however, its object, it is said, is not to impart practical knowledge enabling the student to 'prove all things', but to comprehend the principles on which the scholar of acknowledged scientific eminence proceeds.

"From the viewpoint of the man of science the inductive logics exhibit a painful misapprehension of the nature of science. Whilst investigators move in a world where practical certainty is infrequent and theoretical certainty is almost altogether absent, our logicians discuss, *e.g.*, the philosophy of induction and the precise meaning of the term hypothesis, from a purely speculative and perfectionist standpoint. The great matter, if one may indulge in a sweeping statement, is words, words, words, and the means of illuminating the words is by words, words, words, and the total result is still words, words, words.

"However, the man of science may not be competent to appraise at their true value these discussions aiming at theoretical certainty. What, then, of the considered tests relating to legitimate induction as they appear in the text-books? In this matter one is astonished to note that whilst science has during the last eighty years progressed by leaps and bounds, Mill's rather incomplete analysis of the scientific process has become more and more attenuated, till almost only its bare shadow remains in the more recent books. His five Canons are dutifully quoted and a few words are said in explanation; but the pages devoted to observation, generalisation, and deduction, have dwindled to a diminutive rump.

"Of course, our logicians may retort that the object of their inductive logic is not practical. The difficulty, however, is to discover what purpose, in that case, these manuals are supposed to serve. Are we to assume that the few rules presented on the various aspects of methodological procedure are the only rules, or the most important rules, to be abstracted from the best practice of men of science? They are certainly neither the one nor the other; in fact, one's heart sinks when one meditates that not one of the very able writers on the methods of science appears to have made an actual study of the scientific process in their own labours, or even in those of men of science. Had they done so, they would have much restricted the discussion of terms, only given a page or two to the problem of theoretical certainty, greatly extended the rules, and, with each decade, exhibited an increasing superiority over

Mill's text. Just as any science progresses, so in inductive logic progress would be clearly perceptible when we compared a recent work on logic with Mill's *Logic*. Here, as with deduction, one notices the surprising fact that the expounders of inductive logic are as nearly as possible complete strangers to their subject, if a scientific standard be applied. They offer unintentionally a fundamentally inadequate presentment of the scientific process, and, in this respect, therefore, mislead their readers instead of guiding them aright. Insistence on theoretical certainty, and a conviction that this can be compassed by speculation, mark perhaps every one of these manuals, and render them useless for promoting an understanding of scientific method, for scientific method is no more concerned with theoretical certainty than with pure speculation, but is continuously controlled and guided by carefully ascertained facts, and by the belief that theoretical certainty is an ideal which can only be distantly approached in practice."

§ 71. Even in the physical sciences the lack of a methodology is sometimes strikingly exemplified, witness the works relating to Sound. Here there has been a steady flow of text-books from year to year during the last quarter of a century, with scarcely any perceptible progress, precisely as if the science of sound had already attained to the pinnacle of perfection. Yet on examining these text-books, they as a rule appear plainly to bear the marks of patch-work knowledge, with little order, many lacunæ, not a little of questionable authenticity, and no consciousness of the need of improvement. Surely, in a methodological age, a writer on Sound would make an unprejudiced and exhaustive study of the subject, and appreciably advance the science by filling in gaps, correcting errors, and clarifying concepts. By this day we ought to possess text-books that are virtually complete so far as the main categories are concerned, and that conveyed the truths in question in a lucid and organic manner. Mechanical repetitions, where the problems themselves are not abstruse, should be regarded as reflecting small credit on a work. Nor should the occasional revision or addition of a point or two be deemed adequate. The result of such a poor conception of the role of a writer is that too frequently scientific works are overloaded with traditional matter, and offer little encouragement to the student to pursue the paths of original research. Broadly speaking, he learns his text-book by rote; by rote he later teaches it; and by rote he writes a new text-book. In fact, leaving aside musical acoustics, which has been assiduously cultivated, the last generation or so appears only to muster in England two decidedly stimulating books on Sound—Tyndall's deservedly popular work and Lord Raleigh's masterly treatise.

If traditionalism be one cause of comparative stagnation in science, another is over-specialisation. Like bees fly indefati-

gably from flower to flower and sip drops of nectar in each, so fractional parts of a fractional part of a fractional subject are studied in indeterminate succession. This excludes a comprehensive survey, entails much ambiguity and stumbling in the dark, involves numerous errors and immeasurably great labour, and leaves every science in a ragged and chaotic condition for long periods. Traditionalism and over-specialisation fatally retard the progress of science, and these are largely the result of the lack of an established methodology. Considering the complexity, elusiveness, and vast multiplicity of facts, only a thorough methodology can grapple with them effectively and without the sad waste of an immense amount of energy and time.

Sufficient has been stated to demonstrate the dire need there is of researches, whether they be styled scientific, philosophical, or practical, being methodologically determined and controlled.

CONCLUSION 2.

Need of a Synthetic Methodology, and of a Historical Appreciation of Differences in Methods, and in the Scope of Enquiries.

A.—NEED OF A SYNTHETIC METHODOLOGY.

§ 72. It was the imperishable glory of Bacon not only to have insisted on humbly interrogating nature instead of presumptuously speculating concerning her secrets, but to have recognised the momentous importance of fusing the various scientific methods into one method. Thereby alone, he rightly felt, would the temptation be vanquished to emphasise or employ only certain fractional methods. Our plea in these pages must therefore be both in favour of the utilisation of given methods and of applying these in a certain determinate succession. Such a synthetic mode of discovery will preclude investigators being satisfied with anything short of an exhaustive enquiry.

Allowing for the moment that the following methods are to be applied not only in succession but at each stage of the enquiry according to need, and that we are contemplating what may be designated a complete enquiry, the total process may be summarised in this way: (a) Determination of problem to be inquired into (Conclusions 14–15); (b) Observation, including, where possible, experiment and calculations (Conclusions 16–24); followed by (c) Generalisation (Conclusions 25–28), (d) Verification (Conclusion 29), (e) Interim Statement (Conclusion 30), (f) Deduction (Conclusion 31), (g) Application (Conclusion 32), (h) Classification (Conclusion 33), (i) Final Statement (Conclusion 34), and (j) Report (Conclusion 35).

According to this plan a truth is not to be considered as fairly established when only one or another scientific method

is applied, or when a number of these is fortuitously employed. To attain our end, a mode of procedure has to be resorted to whose initial stage is the determination of the precise problem to be examined and whose final stage is the report. Observation, for example, is hence a mere preliminary to generalisation and admittedly without appreciable significance in the absence of the latter, whilst generalisations which are not verified and are not crystallised into a comprehensive interim definition (itself the introduction to the process of deduction, etc.), remain more or less meaningless. A truth may therefore be said only to be established, or properly inquired into, when (a) to (j) have been applied in orderly succession, no section of the process being omitted and none being utilised out of place.

The logical connection of these methods will, it is hoped, recommend itself on examination. (a) We should, to begin with, naturally be clear as to the nature of the problem with which we are concerned. (Here we are aided by the table of Categories incorporated in Conclusions 3 and 33.) To remain in doubt on this score is to rob the whole enquiry of its meaning. (b) Granted clarity in this respect, it is as obvious that nothing is achieved when no more is attempted, as that the next step should be the examining and ascertaining of the facts, for to generalise or to treat deductively unverified statements would be evidently fatal to solid progress. If the determination of the problem must be and can be only followed by an examination of the facts, it is equally beyond question that the further step is, where possible, resort to experiment, for this permits of observation under relatively ideal conditions. (c) Since the number of particulars in an enquiry is as a rule incalculably great, this distinctly suggests that our goal is not reached, and that we should accordingly somehow arrange or compress these details into classes. The process of generalising follows therefore necessarily on that of observing and experimenting. (d) Yet to generalise is to conjecture that what we think holds true of certain phenomena holds equally true of others, but of that we cannot be sure without verification. Generalisation is hence of necessity succeeded by verification and by nothing else immediately. (e) Fairly embarked upon the process of generalisation, we naturally generalise our generalisations, and this issues in a summary statement or definition, epitomising in the fewest terms possible the results thus far attained. Here apparently our enquiry has reached its natural climax and conclusion. (f) If, however, we probe the matter, we discover that we should be poor indeed if we proceeded no further. In fact, we stand only before the golden gates. The circumspectly formulated summary statement forms an ideal point of departure for the process of deduction, whereby we not only obtain convincing proofs of the general proposition we have reached, but by which we also discover innumerable important truths that

open up new vistas and new enquiries. In fact, we are now reaching in a novel way the truths which it would have been far more difficult to detect by continuing the process of observation and generalisation. (g) We have now learned what we desired on the theoretical side; but this leaves an arbitrary gap, namely, the discovery of the causes whereby the facts are or may be produced, and the satisfaction of men's practical requirements so far as this can be attained through applying the theoretical knowledge acquired. (h) Even now, however, most of our labour may prove futile if the various particular and general facts which we have gathered are not preserved to some extent. We therefore classify our whole relevant material in an order most convenient and profitable for inspection. These classified facts prepare thus the way for our comprehensive definition, as our comprehensive definition illumines them. The two form, as a matter of fact, a single or interdependent totality. (i) This need gratified, we are again threatened with a formless conclusion to our enquiry, and hence we compress our results in a comprehensive definition which, at a glance, can instruct us as to the total outcome of our enquiry. (j) One more step needs to be taken to conclude the enquiry—we must prepare a written report. If we neglect to do this, our imperfect memory and inarticulated memoranda will lead to the loss of the truth which we have toilsomely built up, and, again, if we perform this task indifferently, our statement may be too obscure and will therefore tend to nullify our labours, or it may be so unattractive because of its plain dress that it will arouse practically no public attention. The interdependent and synthetic unity of the scientific process of enquiry is thus readily demonstrated.

As already hinted, two reservations should be made in connection with the preceding statement. Assuming that we are concerned with a complete enquiry, it might be concluded that once our observations are succeeded by generalisation, the process of observation has drawn definitely to a close, and that observation constitutes a self-contained mode of procedure affected by nothing outside itself. Both these assumptions are unjustified. The need for sedulously observing, examining, or calculating, persists through every stage of the complete process of enquiry, while the obverse is also true that each section of the complete process should represent in miniature the complete process. At every stage we shall hence have frequent occasions to observe, to generalise, to verify, to define, to deduce, to apply, to classify, to re-define, and to write. Bare observation, generalisation, etc., most imperfectly satisfy scientific requirements.

More serious is the objection that enquiries are not seldom partial ones, and that therefore the synthetic method is not uniformly applicable. To a certain extent there is a transparent answer to this objection, for enquiries to-day are in countless

instances partial when they should be and might be more or less complete. As we have pointed out in Conclusions 4 and 25 more especially, the contemporary interest in fragmentary enquiries is highly prejudicial and detrimental to the establishment of truth and to rapid discovery, a fact which the tenor of this Conclusion makes almost self-evident. This conceded, however, it need only be remarked that in a necessarily partial enquiry, consonant, say, with Darwin's life-long practice, everything should be done to render it as comprehensive as possible and, as suggested in the preceding paragraph, to introduce into every one of its parts the components of the complete enquiry.

B.—NEED OF A HISTORIC APPRECIATION OF DIFFERENCES IN METHODS AND IN THE SCOPE OF ENQUIRIES.

§ 73. The question of the general standard applicable to methods and to the scope of enquiries is of such far-reaching consequence that it is advisable to associate it closely with the problem discussed in *A*. Without viewing methodological matters in true perspective, there is danger of misapprehending them seriously and becoming enmeshed in delusive and paralysing subtleties. We shall accordingly deal with the subject here at some length.

(a) In *A* we pleaded for a synthetic methodology. In this place, however, we desire to dilate on the historic process which has rendered possible such a system. This analysis should therefore prove useful from more than one point of view.

In methodology, if anywhere, comparisons are odious. One thinker will emphasise the importance of observation, another of experiment, a third of generalisation or deduction, and so on, and the reader will be tempted to pronounce himself in favour of one or another school. The methodological conceptions of different scholars and ages are also commonly judged to be inferior or superior. A historical study of the problems will lead us to deprecate indiscriminate comparisons.

Before much thought had been devoted to deliberate enquiries, even the very notion of method had not suggested itself. At first, with no positive knowledge to guide or check men's cogitations, haphazard thinking and examination appeared satisfactory, since there was nothing to indicate that the results reached were fanciful or well-nigh worthless. Then, slowly, by insensible gradations, sounder knowledge, on the one hand, accumulated, and, on the other, casual experience and reflection were increasingly found to be inadequate and disappointing. Accordingly, one methodological aspect here and another there, rose more and more into prominence. At each fairly developed stage, too, individuals and schools, as now, imagined that the ideal had been at last attained, only however to be superseded by a somewhat higher placed school equally confident of having

arrived at finality. Granted, initially, a virtual chaos and scanty positive knowledge whereby to appraise results, and we can readily comprehend both the gradual and disjointed evolution of methods as well as the step-by-step improvement of particular modes of procedure.

If, therefore, a modern observer appears to us greatly superior, as an observer, to a Lucretius or a Pliny, we ought to seek the explanation in the connected development of positive knowledge and of sounder methods, and not in inborn capacity. Similarly, if the scholars of the Middle Ages implicitly assumed that in the ancients all requisite information was to be found, we shall appreciate their attitude if we place ourselves in their position and recognise how immeasurably great the Latin and Greek classics must have appeared to a people which had practically no contemporary culture. Reliance on authority was therefore defensible in those days. For the same reason, encountering in Aristotle's works the syllogistic method, it was natural for the scholastics to postulate that scientific method and Aristotelian method were one. So, also, with theology filling almost the whole sky of their non-material interests, it was only to be expected that the Middle Ages should have almost exclusively concentrated on the production of theological treatises. Historic reasons, consequently, may be said to proffer almost the complete explanation of the differences obtaining between the mentality of the scholastics and those of our men of science.

Again, consider Roger Bacon's conception of the right method of investigation. As we might expect, the appeal to experience and experiment was growing in his day, and he was only one of the foremost champions of that method. However, representing a rather primitive methodological stage historically, we must not be surprised to discover that his conception of experience and experiment was exceedingly crude and confused, almost a caricature of modern views on the subject. Only protracted collective experience lays bare the comparative defectiveness of any methods in use, and Roger Bacon, as an individual, cannot be therefore charged with gross scientific incompetence.

His namesake, Francis Bacon, occupied a precisely analogous position at a later historic stage. Experience and experiment had enormously advanced—Galileo and Gilbert are apt illustrations of this. About the same period the growth of mathematics and the further accumulation of sifted facts brought also the deductive method into vogue, as Descartes' *Regulæ* strikingly exemplify. In view of this methodological development along multiple lines, Francis Bacon's enthusiasm, as well as his methodological triumphs and failures, are readily understood. He, also, represents primarily a historic stage and epoch, and therefore manifestly could not have been a perfect methodologist.

Gradually thus, more and more, higher and higher, increasingly synthetic, methods develop through the ages. If, then, at some historic stage speculation, observation, or reckless deduction prevails, excellent reasons may usually be cited in justification. Nor may we forget that, since the development is encouraged by but a few social factors, almost at every epoch we encounter the comparatively highest developed and the comparatively lowest developed methods—and their intermediates—socially diffused.

Such, broadly speaking, is the basis for the transitional synthetic methodology which we have presented in the first part of this Conclusion. It is not the result of an intrinsically superior age or of profounder methodological acumen in an individual; it can be only compared with less elaborate methodologies in the light of historical development; and the distant future should be regarded as evolving a far more highly perfected instrument of enquiry than ours is. Above all, our analysis suggests that methods and methodologies are first and foremost historical products, and that therefore evolutionary, and not personal, considerations should primarily enter in any appraisal of their adequacy.

§ 74. (b)¹ A cognate study casts a flood of light on a complementary aspect of profound methodological significance, especially for our day. In § 5 we stressed the unity of nature and life, and endeavoured to show how the domain of science gradually widened until nothing appeared to be excluded therefrom, so much so that even “business” came to be comprehended by it, both on the side of bringing in science as an auxiliary and of reorganising commerce and industry on a scientific basis.

Not infrequently this successive, but often reluctant, admission into the charmed circle of the established sciences has suggested the existence of a sheer struggle between those within and those without that circle, those within appearing to be animated by the selfish motive of reserving for themselves the attendant privileges. Many a successful competitor for this honour tends to regard his entry as a triumph over unappreciative conservatism, and the whole history of this long process is often conceived as a forceful vindication of justice against prejudice. However, here also it is objective considerations which are the prime determining factors in the struggle. Only as one science develops, does the possibility arise of a slightly more complex science developing, and this mode of addition to the established sciences continues through the ages until from the simple science of mathematics we progress, by diverse well-marked stages, to the inclusion of the

¹ The line of thought developed here was first suggested by an examination of the works of Professor Patrick Geddes.

most complicated mental and social sciences. Not schools of thought, theories, or the defeats of conservatives, explain therefore the expansion of the circle of the sciences, but primarily the slow emergence and maturing of one science after another in a necessarily strictly defined order.

The relative status of the sciences is also grounded in historic advance. The more abstract and therefore simpler sciences are *ipso facto* more firmly rooted than the less abstract and more complex sciences, and possess consequently superior authority. In time, however, biology, for instance, became almost austere scientific, and then it was no longer regarded with suspicion. With the passing of a certain number of generations the same remark will come to be applicable to the specio-psychic sciences, until all depreciatory comparisons between sciences will appear out of place.

It was thus the appreciable chaos which ruled down to a few years ago in the practical life, that suggested to scholars the theory that the man of science should keep to pure theory and pure science, and not crave for the fleshpots of utilitarian results. Repeatedly the student was reminded that he could serve practical ends better by ignoring them, and that meddling in the affairs of life advanced neither theory nor practice. The progress of the simpler sciences and the synchronous clarification of practical issues, slowly invalidated this conception of the relation of science to life. Hence it became increasingly practicable for the man of science to devote attention to the life of action, until the distinction between science and the practical life lost much of its point. No one can now doubt that there is illimitable scope for the man of science in industrial laboratories; that commerce and industry are tending to become more and more scientific in procedure; that agriculture in almost all of its aspects is ceasing to be empirical, and is guided at nearly every step by scientific considerations and methods; and that even the more intimate life of health and happiness, come under the control of science. These drastic changes are not the result of changes in theory, but the outcome of the historic growth and purification of experience, which, in turn, is modifying older theories that confused transitional stages with the abiding nature of science.

The law of relativity proceeds a step further in methodology. The man of science was implored to attend closely to his researches, and leave practical deductions severely alone. When this view widely prevailed, that was excellent advice to give. With the simpler sciences, however, becoming surer of their ground, and the life of practice being better grasped, the danger passed away. This, and this alone, justifies our own view, whereon we have laid such stress, that practical deduction should form an integral part of the process of investigation. That is, what at one time was rightly regarded as hazardous, may

now be conceived as a solemn duty. And, indubitably, the more the theoretical and practical sciences will develop, the more peremptory will be the methodological demand that he who is well versed in theoretical science shall not fail to apply his knowledge to improving life along the line of his studies. In fact, we ought to be prepared for a somewhat startling development resulting from the closer contact of science and life. We mean that he who is primarily concerned with the life of practice should, *noblesse oblige*, aim also, both incidentally and systematically, at enriching the realm of theory. In this way the concurrent development of science and practice will lead to their rendering each other invaluable services and eventually coalescing.

We approach now another aspect. Division of labour was one of the earliest phenomena characterising advance in civilisation. Almost all the ancient cultures possessed the caste system. There was the ruling caste, the warrior caste, the priestly caste, the merchant caste, and the labouring caste. By such a division of labour, rigorously enforced, efficiency in a number of directions was ensured. However, the desire for increased efficiency led ultimately to the formation of countless sub-castes or classes. Hence the classical economists fondly dwelt on, and insistently counselled, the minutest subdivision of labour. Consequently, the ideal appeared to them that a factory should turn out, for instance, only needles, only screws, and so on.

The process of scientific development followed the same lines. Thinkers of the olden time, as among the ancient Greeks or Hindoos, took all or most knowledge as their province. As, however, the centuries passed, and material and difficulties accumulated, division of labour was gradually introduced. This process became in time more intensive. Single sciences divided and sub-divided themselves, and the range of interest of men of science assumed insignificant dimensions compared with that of the earliest searchers after scientific truth. So manifold and embarrassing appeared the objective difficulties that specialisation was carried to the point of the investigator concerning himself only with a microscopic portion of a subject. In this way alone, it was held, could science securely advance. The historic process, as above depicted, was its own justification, since necessity was its cause.

Then the theory became popular that specialisation in science was inevitable, and that save for specialisation, and the minutest specialisation, there could be no advance in science. Reality, it was contended, was many-sided and full-blooded, and science a pale, almost featureless, abstraction. Things were complex, but science, it was asserted, could only recognise the separate constituents of these complexes. Truth and scientific truth were regarded as being poles asunder. Inasmuch, however,

as the alternative was to know the separate constituents of reality or nothing at all, the choice was not difficult for the majority of thinkers, though some desired either to grasp reality in its fulness or to abjure the search for truth altogether.

Yet here also we are dealing with a transitional state. The immense ignorance compelled more and more minute division of labour in science, and demanded virtually exclusive attention to a narrowly circumscribed speciality. This was unfortunately carried so far that in numberless cases hundreds of unconnected and petty enquiries were conducted by individual men of science. Against the continuance of this trend we have repeatedly protested in this volume, though even here the method was probably suggested at first by the impracticability in certain historic stages of a subject, of doing more than just touching the fringe of a small fringe of a general fact.

With the accumulation of organised data to a certain point, extreme specialisation seemed to be inevitable; but as the store of important scientific material assumed ever more formidable dimensions, a new methodological theory, widely diverging from that prevalent a century ago, developed.

To begin with the practical life. The local trade union, limited to one craft, entered into relations with similar unions in adjacent localities. In the process it gained experience sufficient to enable it to federate with other local unions, further afield. New experiences gradually rendered it practicable to form national and international unions. Tentative efforts were also concurrently made to federate with cognate unions and to form unions comprising a whole general branch of industry until, once more with growth of experience, eventually the whole of labour, professional, skilled, and unskilled, was organised in unions, and these unions were welded into a single national and, partly to anticipate, international federation.

Firms also profited by experience, and were thus enabled to establish many scores of agencies and branches. Numerous firms, interested in a certain speciality, amalgamated, until maturing experience permitted all the firms of a country, and even of several countries, who carried on a certain trade, to form into one company. Such combines or trusts found it advantageous to absorb auxiliary trades, with the result that stupendous economic organisations came to be formed and successfully conducted. Nor is this apparently the end of the process. Increased knowledge of organisation has enabled companies to manage numerous businesses having no special relations to one another, to establish factories where widely differing articles are produced, and to dot the country with "universal" stores selling almost every conceivable commodity and ready to perform a multiplicity of other services.

With growth of experience, as we have seen, division of labour tends almost to disappear in the practical life. This

is also the case in the scientific sphere. Greater knowledge enables the man of science to abandon mere flashes of enquiries. It places him in a position to set himself comparatively extended tasks. Much sifted knowledge being accessible, he is enabled not only to study a whole subject, but, in doing so, to profit by the conclusions reached in connected subjects. Lastly, circumstances justify him frequently in dealing with a series of allied subjects.

The antithesis between reality and scientific truth, between specialisation and generalisation, is thus passing away. The significance of this it is difficult to exaggerate. Fractional studies seemed to be essentially irrational in a world of complex realities. They were remote from life, and appeared to yield little insight into the great facts of being and becoming. The world of science seemed to form a universe of its own, almost in challenging and crying contradiction with the world of the senses and the reason. No wonder, then, that those of little faith turned away from science in despair. Science is, however, vindicating itself before the bar of history. The way to reality lay through specialisation and through an intimate knowledge of component facts, and once this was attained, division of labour began to be more or less widely superseded by comprehensive activities. For the far-off future, therefore, narrow specialisation will only exist at the outskirts of the world of knowledge, and large synthetic studies will be the rule. Science will be then truly science and verily reflect reality.

Already at the end of § 5 we had occasion to direct attention to the ponderous block of sound knowledge in existence to-day. These blocks are being progressively more utilised. Is it a question of diet? He who is interested in the subject may take into account the principal and other dietetical constituents of food and foods, the accessory food factors or vitamins, the aeration of the blood, and the need of water—all quantitatively and qualitatively considered, and allow for age, season, profession, hour of day, breaks between meals, etc. The problems of mastication, digestion, assimilation, and rejection, with the connected problems of anatomy, physiology, and growth, also temperament, serving and enjoying of food, exercise and rest, general health of mind and body, habits, cost, requirements of the community and of humanity, may be all more or less definitely envisaged by the investigator.

Is it a question of agriculture? He who is concerned with it may learn much pertaining to general and local climatology, drainage and irrigation, plants and variety of plants suitable for special soils, the best manures, means of countering insects and germ pests, the most efficient labour and machinery needed, the organisation desiderated for success, the demands of the markets near and far, the advantages of co-operation, etc.

Is it a question of town-planning? Local climate, geography, geology, mineral wealth, configuration of district and town, fauna and flora, surface soil, physical, economic, and other relations of locality to neighbouring localities and nearest large towns, building materials, roads, ventilation, heating, and lighting of buildings, water-supply, sanitation, hygiene, open spaces, outdoor and indoor amusements, schools, public buildings, churches, theatres and art institutions generally, industries and commerce, past of town, customs and traditions of townsmen, reconciliation of past and present ideals in town-planning—almost all of these can be examined in a fairly scientific spirit.¹

In science in the narrower sense the same possibilities are emerging. In studying such a subject as light, for instance, not only can, besides special aspects, the entire field be covered, but serious notice can be taken of the affiliated etheorological or corpuscular sciences of heat, electricity, magnetism, radiation, and even chemistry, without passing over the practical problems of indoor and outdoor lighting. In this manner, much of the crudity inseparable from earlier attempts can be successfully avoided. So, too, the geologist may aim at being thorough, taking effective note, primarily through the existence of a number of somewhat highly developed sciences, not only of the sheer spatial and chronological succession of rocks and their component parts and contents, but of the factors responsible for these—effects of gravity, pressure, heat and cold, fire and frost, moisture and dessication, lightning, atmospheric and water currents and water generally, chemical changes in rocks, subsidence and raising of land, earthquakes, volcanoes, and hot springs, age of the rocks, position and distribution of strata on the globe, far-reaching climatic changes in the course of the earth's history, plants and animals and their actions and remains, human interference, and the like. In a similar way the meteorologist very largely depends on a multitude of data collected by sister sciences. The chemist also can study the important mechanical, physical, crystallographic, and vital aspects in connection with his department of knowledge. The biologist, too, in striving to understand the nature of life and of life forms, may call to his aid almost scores of passably developed sciences. Lastly, in the future the various mental and social sciences will be as readily and as profitably utilised in education, æsthetics, morals, religion, civics, and politics. In any case, the day appears to have definitely arrived when narrow specialisation, except in rare instances, is becoming a grave offence against present-day methodological demands.

¹ A brilliant example of town-planning may be found in *Town Planning towards City Development*. A Report to the Durbar of Indore. 2 vols. 1918. By Patrick Geddes.

A good general illustration of this advance in science is offered by descriptive works pertaining to countries. The volume may open with a geographical, geological, and climatological survey, and may describe the terrestrial and aquatic fauna and flora. It may give an account of the races and stocks inhabiting the country, and a brief history of the people, with some reference to neighbouring countries. It may enlarge on its mineral and forest wealth, on the productivity of the land and the nature of its crops, on the utilisation of pastures, and on its principal trades. It may speak in precise terms of its political constitution, its laws, its army, navy, and air force, its local administrations and local activities, its family life, its educational system, art, science, religion, and recreation. It may furnish vital statistics, statistics of commerce, industry, and finance, and of agriculture, forestry, and live stock; and afford, in a word, a tolerably correct general picture of the organisation and of the life of the men, women, and children inhabiting the country. Two centuries ago such a comprehensive statement, if attempted, would have proved a tissue of fantastic guesses and misinterpretations.

We are doubtless only at the threshold of the synthetic or realistic age. For this reason, with the encouragement must go a warning. In proportion as there has been little specialisation, as generally in the mental and social sciences, synthetic procedure is non-scientific if not anti-scientific, and therefore only in proportion as there are *scientifically* sifted facts and generalisations, are we justified in having recourse to the synthetic method. Mere logical webs, constructed out of commonsense knowledge and shrewd surmises, are strangers to science.

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Growth through the ages is responsible for the diverse stages of science and its method, as observed from various historic angles. It is primarily a process of objective evolution. Necessarily therefore the single individual is scarcely more than a mirror of his age, and his theories, couched generally in finalistic phraseology, constitute roughly only a valid defence of the scientific *status quo*. A dynamic conception of scientific advance should prove an effectual solvent of many long-standing controversies, and enable us to discern, and take advantage of, the direction in which science and methodology are moving.

CONCLUSION 3.

Need of Fixing Methodologically the General Nature and Relations of Phenomena.

§ 75. Having ascertained that an enquiry should be conducted in conformity with methodological canons, and having decided that these canons form a synthetically connected unity, we

shall now proceed to state the most general nature of the facts to be examined. We might have simplified our task by merely enumerating for this purpose Aristotle's Categories—Substantia, Quantitas, Qualitas, Relatio, Actio, Passio, Ubi, Quando, Situs, and Habitus;¹ but his list of predicaments unfortunately no longer satisfies scientific requirements. Consequently, we have ventured to submit new lists of categories which, however, lay no claim to completeness or finality. To have neglected this delicate and responsible task altogether because of the difficulty involved in its adequate execution, would have left a gaping void in the methodological scheme propounded in this volume.

I.—INTRODUCTORY CATEGORY.

§ 76. We might say that the object of any enquiry is always to determine the partial or total nature, and sometimes relations, of a fact. *A fact, again, we might define comprehensively as a given or stated partial (e.g., portion of individual), single (e.g., individual as a whole), collective (e.g., aggregations of individual to species), grouped (e.g., beyond species, and including larger wholes such as a science, or a group or groups of sciences, to cosmology and the universe), or abstracted (whiteness, etc.), physical or other something (i.e., anything which partially or wholly exists, is coming into, or going out of, existence, has existed, will, might, could, would, should, or is believed, alleged, or feigned to, exist, or the contrary).* Liberally interpreted in this way, room is probably provided for most orders of fact which obtrude themselves on the intelligence, and assistance is thus afforded in the most elementary forms of classification.

II.—PRIMARY CATEGORIES.

§ 77. The Primary Categories may be profitably divided into three main sections, and may be said to aim at indicating and helping to ascertain the general nature and relations of phenomena to be determined in an enquiry :

(1) Material Aspects	} of a phenomenon investigated.
(2) Modal Aspects	
(3) Procedure Aspects	

(1) *MATERIAL ASPECTS*.—The material aspects practically include the bare facts alone, irrespective of anything measurable or changeable.

¹ According to Mill "all the assertions which can be conveyed by language express some one or more of five different things: Existence; Order in place; Order in Time; Causation; and Resemblance. Of these, Causation, in our view of the subject, not being fundamentally different from Order in Time, the five species of possible assertions are reduced to four." (*Logic*, bk. 3, ch. 24, § 1.)

We classify them as follows:—

1. Elementals	of phenomenon	} ungeneralised phenomenon.
2. Constituents	"	
3. Form	"	
4. Dependence	"	
5. Action	"	
6. Cause	"	
7. Resemblances	of phenomenon	} phenomenon classed.
8. Classification	"	
9. Position	"	
10. Differentiæ	of phenomenon	} phenomenon defined.
11. Details	"	
12. Value	of phenomenon	} worth of phenomenon.
13. Utilisation	"	
14. Appreciation	"	
15. Description	of phenomenon	} description of phenomenon.

This skeleton does not, however, offer its own explanation. We shall therefore develop each of the sub-sections:—

A.—Material Aspects of Phenomenon Investigated:—

1. ELEMENTALS, or Precise fundamental *sensory and other mental data* sought for in physical or mental investigations: (a) *vision*: light—colour—shade—transparency—picture—appearance; (b) *touch and effort*: softness—smoothness—evenness—cohesion—plasticity—flexibility—malleability, configuration—texture, gravity—weight—pressure—resistance, attraction—repulsion, fluid—liquid—viscid—solid; (c) *hearing*: sounds—noise—harmony; (d) *taste*; (e) *smell*; (f) *heat*; (g) *feeling*: pain—pleasure—appetite—desire—mood—excitement—emotion—sentiment; (h) *volition*: impulse—habit—decision—willing—action; (i) *intelligence*: observation—memory—imagination—reasoning—judgment—reflection; and (j) *indirectly apprehensible*; causes of heat, electricity, magnetism, etc., and unconscious cerebration;

2. CONSTITUENTS, or Precise static and dynamic, largest to smallest, *constituents*, including ether, elements, compounds, minerals, vital constituents, materials, and parts, and their precise disposition, connection, interdependence, and relative homogeneity or heterogeneity;

3. FORM, or Precise *form*, shape, outline, design, of wholes, parts, sub-parts, etc., and their precise disposition, connection, interdependence, and relative homogeneity or heterogeneity;

4. DEPENDENCE, or Precise special facts and factors in the environment on which the phenomenon is more or less *dependent* (e.g., tree's dependence on soil, atmosphere, and external temperature);

5. ACTION, or Precise *action* or effects of phenomenon;

6. CAUSE, or Precise *cause* or causes of the existence and properties of phenomenon;

7. RESEMBLANCES, or Precise leading, major, and minor individual, class, and other *resemblances* of phenomenon or phenomena (for forming classes and schematic scale of classes);

8. CLASSIFICATION, or Precise methodical *classification* of the phenomena observed, and placing the classes thus formed under a more comprehensive category;

9. POSITION, or Precise *comparative position* of phenomenon within class or classes, and precise comparison of the parts of related wholes;

10. DIFFERENTIÆ, or Precise leading, major, and minor individual, class, and other *differentiæ* of phenomenon (the ascertainment of the leading *differentiæ* is the primary object of most investigations);

11. DETAILS, or Precise *secondary aspects* or details of phenomenon of interest in the enquiry;

12. VALUE, or Precise *value* and *quality* (hygienic, economic, moral, æsthetic, philosophical, scientific, . . .) of phenomenon;

13. UTILISATION, or Precise *utilisation, application, and reproduction* of phenomenon in all spheres of life;

14. APPRECIATION, or Precise *appreciation* (desire, liking, preference, love, and enjoyment, and their opposites) of phenomenon;

15. DESCRIPTION, or Precise *nomenclature, terminology, definitions, formulæ, statements, tables, diagrams, and reports* in connection with the phenomenon.

Compressed, and evidently incomplete, as the immediately preceding statements are, they ought nevertheless to throw a blaze of light on the path which the investigator has resolved to travel on. They should second him in the arduous task of ascertaining everything material to his enquiry and of preventing his overlooking anything of moment. At present short-sighted tradition and fumbling practice are his guides, supplemented by his own narrow experience and the imperfect criticisms of others. However, such subserviency to the mercy of chance is to be deprecated. Methodological pioneers should have preceded him and made his progress as rapid as circumstances permitted. It is the very essence of cultural advance that the obscure shall be illuminated, and that established facts and methods shall be collected, methodised, and placed within the easy reach of all. Nor does the tentativeness of the list prepared seriously matter, for the inquirer must be expected to expand and supplement the statements, as far at least as his subject of enquiry is concerned.

(2) *MODAL ASPECTS*.—Slightly arbitrary as any division must be, it may nevertheless lay claim to certain advantages. This apparently applies to the division of the Primary Categories into Material and Modal Aspects, for it enables us to separate what is mainly material from what is mainly modal. The Modal Aspects are:—

1. Quantity.
2. Time.
3. Space.
4. Consciousness.
5. Degree.
6. State.
7. Change.
8. Personal Equation.

These eight aspects may be profitably developed as hereunder:

B.—Modal Aspects of Phenomenon Investigated:—

1. *Quantity* (precise number—magnitude—calculation . . .);
2. *Time* (precise position and distribution in time, precedence—succession, number of times, dawn—day—twilight—night, seasons, past—present—future, duration—age—date, frequency—periodicity, rapidity—slowness, velocity—acceleration—retardation, chronological measurement and chronological calculation generally);
3. *Space* (precise position and distribution in space, before—behind—juxtaposition—direction, magnitude, number, height—depth—breadth, length—distance, angle, degree, longitude—latitude, compass points, metrical and other measurements and calculation generally);
4. *Consciousness* (precise position and distribution in consciousness, precedence—succession, magnitude, number, vividness—completeness—durability, movement—changes, and resemblance in these respects of recalled phenomenon to phenomenon recalled, chronological, comparative, and other measurements, and calculation generally);
5. *Degree* (precise degree of Material, Modal, and Procedure Aspects, of mathematical, etheorological, mechanical, physical, chemical, crystallographical, vital, sensory, psychological, social, specio-psychic, and other properties and relations of a static or dynamic character, and of resemblance, difference, dependence, interdependence, and other relations and interrelations, quantitatively stated where possible);
6. *State* (precise pure, average, casual, momentary, time-produced, environment-produced, individual, transitional, exceptional, abnormal, perfect, imperfect, and . . . state);
7. *Change* (precise movement—activity—process, from commencement of change to its end, external and non-external influences, fertilisation—kariokinesis—prenatal development—birth—growth—adaptation—regeneration—reproduction—senescence—death—decomposition, evolution—origin—history—development—transformation or dissolution and further evolution, improvement—deterioration, production—accumulation—distribution—exchange—consumption, experiencing—feeling—reasoning—concluding, automatic—reflex—impulsive—habitual—deliberate action, and ways of living and their formation and change . . .); and
8. *Personal Equation* (precise degree of more or less complete interest—preparedness—liberty—opportunity, of possessing stranger's freshness in viewing and weighing own facts and conclusions, and of more or less permanent individuality, abnormality, unclearness—ignorance—error—prejudice—deception, and . . .).

Manifestly our remarks regarding the value for the inquirer of the Material Aspects, apply with equal cogency to the Modal Aspects.

(3) *PROCEDURE ASPECTS*.—The justification for the inclusion of these in the Primary Categories is chiefly practical. They are manifestly a mere selection, as the subsequent Conclusions will show. Nevertheless it is well to concentrate attention right at the commencement on certain methodological master modes of procedure. Since the statements either explain them—

selves or are explained later, it will suffice to submit them without comment in this place. They are:—

C.—*Procedure Aspects of Phenomenon Investigated:—*

1. Precise determination of the problem under investigation. (Conclusion 14.)
2. Accurate, minute, and, if possible, experimental examination, under the most varied conditions of space, time, and other circumstances, and immediate and scrupulous recording of results. (Conclusions 16, 18.)
3. Alertness, in order not to miss obscure, unobtrusive, and exceptional facts. (Conclusion 21.)
4. Systematic exhaustion, plus simple case and testing of divisions. (Conclusions 19, 20, 17.)
5. Degree-determination and dialectics. (Conclusions 27, 28.)
6. Luminous clearness and decided definiteness in thinking. (Conclusion 15.)
7. Graded, comprehensive, important, numerous, full, rational and relevant, original, automatically initiated, and methodically developed generalisations, deductions, and applications. (Conclusions 25, 31, 32.)
8. Systematic verification, classification, balanced interim and final statements, and lucid reports. (Conclusions 29, 33, 30, 34, 35.)¹

¹ Originally it was contemplated that the Primary Categories should be followed by Secondary Categories which should offer a conspectus of the methods to be applied in investigations. This intention was finally abandoned because of the danger involved in abbreviated statements. However, it may not be amiss to print the original draft in a footnote, if only because the draft is suggestive and has been utilised here and there in this treatise.

Secondary Categories.

(a) PURPOSE.—State what is the precise object of the enquiry, and roughly define the meaning of this object and the chief terms employed.

(b) EXISTENCE.—Examine whether the alleged phenomenon exists at all (*e.g.*, men having tails), or whether its existence is relatively doubtful (*e.g.*, normal case) or relatively indubitable (*e.g.*, human beings having eyes).

(c) INDEPENDENCE.—Examine whether the alleged phenomenon is wholly or partly unique (*e.g.*, elephant's trunk), or to what degree it may be part of a more comprehensive phenomenon (*e.g.*, the ethical term Ought), or composed of various (*e.g.*, popular conception of grass or of a cold) or varying (*e.g.*, law, religion, or living according to nature) phenomena, or entering largely or otherwise into other or all phenomena (*e.g.*, human equation).

(d) INTERRELATION.—Examine the degree of the phenomenon's dependence on preceding and co-existing, conditioning of co-existing and succeeding, or other relation to preceding, co-existing, and succeeding phenomena of an identical or non-identical character (*e.g.*, the digestive process).

(e) EXTREMES.—Examine the phenomenon, from its one or more minimal, through its one or more perfect or normal, to its one or more maximal stages, for the purpose of determining its various phases (*e.g.*, history of civilisation).

(f) DEGREE.—Examine whether differences of degree relating to any aspect make any fundamental or what difference to the conception of the phenomenon and whether the phenomenon is related to other phenomena by a chain of degrees (*e.g.*, the evolution of species or of the solar system).

(g) EXPERIMENT.—Examine, by gradually eliminating and also adding, one by one and also in groups and in differing quantities, the alleged static and dynamic constituents of the phenomenon, in order to determine the real constituents (*e.g.*, in chemistry).

Conclusion 17 will complete our statement concerning the general nature and relations of phenomena by dealing with the subtle problem of the mode of determining what are, and what are not, primary static and dynamic facts.

CONCLUSION 4.

Need of a Life-Time Object of Enquiry.

§ 78. Considering the full statement of the general problem of methodology presented in Section XIX, and the thirty-two Conclusions which succeed this one, it is only necessary to offer the briefest account of the nature of the problem with which this Conclusion is concerned.

The wider object of science is to determine the most general facts or laws of nature by methods likely to achieve this end conveniently, rapidly, and satisfactorily. According to circumstances, an inquirer may select one or another field of study, and pursue his investigations for a shorter or a longer period. Leaving sundry accidental alternatives on one side and only contemplating the ideal norm, we may say that the fully equipped inquirer should propose to himself as weighty a problem as a life-time of endeavour (say—intermittently or uninterruptedly—twenty-five years of ardent devotion) may reasonably be expected to promote substantially. From Conclusion 5, it will transpire what are the general limitations, and from Conclusion 25*c* why one comprehensive problem only, rather than many minor ones, should be selected for examination.

In regard to the particular question to be elucidated, no guidance can be offered save that by preference one of the many salient problems of the age should be attacked (§ 167),

(*h*) MODALITY.—Examine, stage by stage, or continuously, the phenomenon's modal aspects, according to the second table of Primary Categories.

(*i*) DIALECTICS.—Examine, following Conclusions 27 and 28, for facts possibly contradictory, contrary, opposite, etc., to those alleged to have been established in or between wholes and parts of wholes (*e.g.*, are men born good?).

(*j*) COMPARISON.—Examine the phenomenon under profusely varied conditions of space, time, and other circumstances, including phenomena most similar and most dissimilar both as regards wholes, parts, and degree (*e.g.*, race superiority).

(*k*) RELATIONS.—Examine the degree of the phenomenon's relations to the science immediately in question and its applications, to the sciences immediately related to that science, to the more remotely related sciences, to the sciences and arts generally, and to the specio-psychic sciences and their corresponding practical activities (*e.g.*, some æsthetic problem).

(*l*) STATEMENT.—Examine the degree of the phenomenon's relation to closely, less closely, and distantly connected phenomena in order to reach the most relevant general statement (*e.g.*, the sense of sight), and furnish, after the fullest investigation, the tersest, most lucid, most definite, and most comprehensive statement practicable of the peculiar nature of the phenomenon, both as regards theory and practice, which approaches complete exactness, and is offered as far as possible in mathematical form.

since sufficient general progress has been made to permit the inquirer to pass down almost every great avenue of thought and life—from mathematics to politics. Perhaps a day may arrive when an international academy, having the progress of science in trust and at heart, will sketch, without prescribing, the channels in which research at any period can be most profitably directed, and may coordinate the labours undertaken collectively or individually. In our day, and probably for some appreciable time to come, this has to be left almost altogether to hazard (Conclusion 12), and nothing can be done except to urge that an important enquiry should be only initiated after adequately considering the general contemporary condition of science, and the predilection, preparedness, opportunities, and resources of the inquirer (§ 86).

CONCLUSION 5.

Need of a Simple Starting-Point.

§ 79. This is a Conclusion the practical importance of which can scarcely be exaggerated. Its principal object is to emphasise the historical and pan-human nature of truth, and to warn against precipitate attempts at reaching conclusions prematurely. Bacon desired to make all knowledge his province; Descartes contemplated the same end; and philosophers, generally speaking, have often evinced no adequate appreciation of the measured growth of truth through the ages. The question, then, raised by this Conclusion is When may we legitimately institute an investigation? Shall we begin with the simplest facts or with the most complex ones? Shall we take up problems where others have left them, or shall we disregard the efforts of others? Or does the starting-point not matter?

In Section IV we learnt that in spite of the fact that men had always attempted to resolve problems of every grade of intricacy, and preferably the more intricate ones, the history of science unmistakably evidences that all endeavours to grapple with the more intricate problems before the simpler ones, have, without exception, issued hitherto in failure, and that the body of scientific knowledge has historically grown from the simple to the complex.¹ The conclusion is therefore irresistible that any breaking loose from organic succession with past scientific

¹ This determinate sequence is well expressed by Henry Balfour, in the Introduction to a work by A. Lane-Fox Pitt-Rivers, on the *Evolution of Culture*, 1906. "Every form [in cultural products] marks its own place in sequence by its relative complexity or affinity to other allied forms, in the same manner that every word in the science of language has a place assigned to it in the order of development or phonetic decay." (P. 12.) "Progress is like a game of dominoes—like fits on to like. In neither case can we tell beforehand what will be the ultimate figure produced by the adhesions; all we know is that the fundamental rule of the game is sequence." (P. 19.)

thought will avenge itself, and that we should not commence an investigation where the simpler facts are as yet unexplored, unless indeed we set ourselves the task of ascertaining the simpler facts. Elementary mathematics, concerned as it is with idealised facts of the most primitive order was therefore the first science, and cosmology, as the science of sciences, will, because of its stupendous complexity, be the last. The latter depends on the triumph of the physical, as well as of the biological and cultural, sciences, and since all, save the first, are in their childhood, philosophers must yet for a long time wander in the wilderness.

If Darwin had not had at his disposal the socially collected facts relating to geology, palæontology,¹ zoological and botanical morphology and physiology, embryology, the geographical distribution of animals and plants, and domestic breeding, and still had pressed on the attention of the public his theory of natural selection, he would have been an idle dreamer, and not the honoured man of science he was. However, the assistance lent to Darwin went even further. The evolution theory had been popularised by Buffon, Lamarck, and Geoffroy St.-Hilaire in France, and by Erasmus Darwin, Lyell, Chambers,² Herbert Spencer, and sundry others, in England; the curious tale told by the rocks forced biologists to speculate concerning the genesis of species, and the principal dynamic fact in Darwin's theory was supplied by Malthus.³ A close historic survey would probably reveal that Darwin's conception was in the air and would have developed irrespectively of him, as is in reality illustrated by Alfred Russell Wallace arriving independently, and about the same time, at the same conclusion. In 1851 the *Outlines of Comparative Physiology touching the structure and development of the races of animals living and extinct*, by Louis Agassiz, appeared in a second edition. In this work, itself the development of an earlier one, the last chapter terminates with a series of conclusions, whereof the

¹ "Since *The Origin of Species* was written, our knowledge of this record has been enormously extended, and we now possess, not complete volumes, it is true, but some remarkably full and illuminating chapters." (W. B. Scott, Chapter on "The Palæontological Record [I. Animals]," in *Darwin and Modern Science*, ed. by A. C. Seward, 1909.)

² "Chambers himself only gave unity to thoughts already in wide circulation." (Quoted from A. W. Benn, by A. C. Haddon, *History of Anthropology*, p. 61.)

³ "Darwin's great achievement was to formulate this law; though it is only fair to add that it was discovered by A. R. Wallace at the same moment. Both of them got the first hint of it from Malthus." (R. R. Marett, *Anthropology*, p. 69.) The theories of both Malthus and Darwin, again, were reflections or expressions of the competitive spirit in social affairs prevalent in their time. (See G. Papillault, in *Le progrès*, 1913.) This method of tracing the origin of ideas to other than logical or speculative sources is admirably illustrated in those works of Rudolf Eucken which deal with the history of philosophy.

first one is highly significant for our purpose: "From the above sketch it is evident that there is a manifest progress in the succession of beings on the surface of the earth. This progress consists in an increasing similarity to the living fauna, and among the vertebrata, especially, in their increasing resemblance to man." (P. 417.) Sir John Herschel had, by 1830, adumbrated Agassiz's conclusion which evidently demanded a naturalistic explanation. He speaks of "a series of periods of unknown duration, in which both land and sea teemed with forms of animal and vegetable life, which have successively disappeared and given place to others, and these again to new races approximating gradually more and more nearly to those which now inhabit them, and at length comprehending species which have their counterparts existing". (*Discourse*, [316.]) In 1887 Grant Allen wrote *à propos* of this subject: "The species that bear most closely upon the theory of organic evolution are almost all of them quite recent additions to our stock of knowledge. The gorilla appeared on the scene at the critical moment for *The Descent of Man*. Just on the stroke when they were most needed, connecting links, both fossil and living, turned up in abundance between fish and amphibians, amphibians and reptiles, reptiles and birds, birds and mammals, and all of these together in a perfect network of curious cross-relationships. Lizards that were almost crows, marsupials that were almost ostriches, insectivores that were almost bats, rodents that were almost monkeys, have come at the very nick of time to prove the truth of descent with modification." (*The Fortnightly Review*, June, 1887, p. 882.)¹

In the matter of observation, therefore, the succeeding Conclusions would offer fatuous suggestions if this Conclusion were not respected. If Darwin's time had been as ignorant of geology and of the other sciences adverted to above, as the times of Erasmus Darwin and of Lamarck were, the subject of the origin of species would have been enveloped in such obscurity that Darwin could have made no sensible progress in unpicking the knot of facts. He would have struggled in vain to develop half-a-dozen intricate sciences to serve as his point of departure, and very likely he would have finished by accomplishing just something in one science or another, never coming even within hailing distance of the solution of the problem he was interested in, and never being regarded as a man of surpassing genius.

Moreover, in the light of fifty years of post-Darwinism, we can more justly appraise Darwin's contribution. We thus learn of numerous radical criticisms of his theory. It is said that we ought to speak of a struggle for comfort rather than of a

¹ For a further statement of pre-Darwinism, the reader is referred to the author's forthcoming work, *The Distinctive Nature of Man*, ch. 9.

struggle for existence; that affection and mutual aid occupy a prominent place in the development process; that evolutionary progress is "essentially through the subordination of individual struggle and development to species-maintaining ends" (Geddes); that acquired characteristics are not inherited; and that human progress is cultural and not biological. Finally, the Mendelians are furnishing certain reasons for surmising that many so-called variations are post-natal and are not inherited; that true variations are frequently due to a re-shuffling of unit characters; that variations are more likely to be sudden, large, and definite, than slow, small, and intermediate in form; and that other factors, besides the natural selection of favourable variations, require to be considered in accounting for the evolution of living forms.¹ Hence it transpires that Darwin effected little more than to marshal in a persuasive form the evidence in favour of the theory that the variety of living forms is intimately related, and that natural forces could be conceived explaining the metamorphosis of species.² This case eloquently illustrates the folly of tracing world-moving ideas to the fortuitous discovery of some preternaturally endowed individual.

In conformity with this Conclusion, then, the scientific worker should seek to extend some particular field of labour, or, if he inaugurates some new science, it should not be one which depends materially on other not yet developed sciences. In any case, he would not think of investigating a problem where the facts are at once decidedly complicated and very imperfectly known to men of science. *It may be said that the order of fruitful investigation is the order of the sciences as commonly classified at the present day*, beginning somewhere with mathematics and terminating somewhere with applied ethics.

We might epitomise the Conclusion in the following rule: "In initiating an enquiry, begin with what is scientifically determined; but if nothing relevant is thus determined, ascertain the commencement of the simplest relevant elements, and proceed thence in a forward direction, unless the beginnings lie far back or are complicated, in which case abandon the enquiry." In connection with this rule these two sub-rules may prove useful: (a) "Only that is to be regarded as well-ascertained which has been investigated and tested scientifically." (b) "All commonly accepted statements, not the outcome of scientific

¹ Two of the leading modern works on organic evolution are E. Weismann, *The Evolution Theory*, 1904, which aims at disproving the inheritance of acquired characteristics, and Hugo de Vries, *The Mutation Theory*, 1910-1911, which argues in favour of sudden, large, and definite organic variations. Bateson's *Mendel's Principles of Heredity*, 1909, ably expounds and develops the new principles of heredity.

² "The commanding superiority and wide scientific influence of Darwin among naturalists are of course popularly, though groundlessly, associated with the origin instead of the final popularisation of the conception of descent." (Article "Biology", in *Chambers' Encyclopædia*, 1908.)

research, are, at best, true and useful for practical purposes only.”¹

The fundamental thought incorporated in this Conclusion should even guide those who are desirous of acquiring a knowledge of the sciences. As Comte points out: “Physicists who have not first studied Astronomy, at least under its general aspect; chemists who, before applying themselves to their special science, have not previously studied Astronomy and then Physics; physiologists who have not prepared themselves for their special labours by a preliminary study of Astronomy, Physics, and Chemistry: all these lack one of the fundamental conditions of their intellectual development. This is still more evident in the case of students who wish to devote themselves to the positive study of Social phenomena, without having in the first place acquired a general knowledge of Astronomy, Physics, Chemistry, and Physiology.” (*The Fundamental Principles*, etc., p. 59.) Truly, as we have seen, all the sciences, arts, and crafts grow to be intimately and organically connected.²

CONCLUSION 6.

Need of Shunning Vagueness and Over-Subtlety in an Enquiry.

§ 80. Every attempt to fasten in haste on an observation, or for the matter of that on a proposition, and lose oneself therein, is fatal to rapid progress. Where, therefore, a problem is not definite in character, it should be approached and attacked from a score of points, and rather than plunge into subtleties, the problem, as in craniology,³ for instance, should be waived

¹ “Words, being commonly framed and applied according to the capacity of the vulgar, follow those lines of division which are most obvious to the vulgar understanding. And whenever an understanding of greater acuteness or a more diligent observation would alter those lines to suit the true divisions of nature, words stand in the way and resist the change.” (Bacon, *Novum Organum*, bk. 1, 59.) “The rational school of philosophers snatches from experience a variety of common instances, neither duly ascertained nor diligently examined and weighed, and leaves all the rest to meditation and agitation of wit.” (*Ibid.*, bk. 1, 62.)

² On reflection, it will become evident that an astronomer who is ignorant of everything except astronomy, is likely to make grave mistakes as a consequence. The recently developed problems relating to astro-physics, astro-chemistry, and what one may call astro-biology, illustrate this. In addition, the question of the personal equation including health, and that of comprehending others and communicating to them intelligibly his researches, involve a corresponding knowledge of biology and specio-physics. We may proceed even further, and point out the need, not only of the astronomer being initiated into the mysteries of the life of practice, but of the practical man and the artist not being neophytes in the domain of science. In fine, sober thought suggests that every man, whatever his speciality, should be highly cultured in the fullest sense of the word.

³ The following quotation from Dr. A. C. Haddon’s *History of Anthropology*, 1910, well illustrates to what length uncontrolled specialism leads: “Dr. Hagen

for a time or its solution abandoned altogether. Or it may be allowed to stand admittedly imperfect, for time is precious and subtlety is the thief of time. Most likely, as the general problem approaches solution, the special problem will also be clarified. Subtlety is the complement of reckless generalisation, and ends in hair-splitting and in deeper subtleties. Of course, the implication here is that we are treating of the separate aspects of a larger problem rather than of the larger problem itself. The problem should not, naturally, be left shrouded in anything like complete doubt *at the end* of the enquiry. It is interesting and important to notice in this connection that *Aristotle's works almost remind us of note-books where, on the basis of personal and relatively unbiassed study, conclusions*

relates the extreme specialisation into which craniologists were led: 'A rage for skull measurements, vast, vigorous, and heedless, set in on all sides, especially after Lucaë had discovered and perfected a method of accurately representing the irregular form of the object studied. More skulls, was henceforth the war-cry; the trunk, extremities, soft tissues, skin and hair. might all go by the board, being counted of no scientific value whatever, Anthropologists, or those who aspired to the title, measured and delineated skulls; museums became veritable cities of skulls, and the reputation of a scientific traveller almost stood or fell with the number of crania which he brought back with him.

'After two decades of measuring and collecting ever greater quantities of material from foreign lands, and from the so-called primitive or aboriginal races, the inadequacy of Retzius's method became apparent. Far too many intermediate forms were met with, which it was found absolutely impossible to classify by its means. In accordance with the suggestion of the French anthropologist Broca, and of Welcker, Professor of Anatomy at Halle, a third type, the so-called Mesocephalic form, was interposed between the two forms recognised by Retzius. Even this did not suffice, however. In the face of the infinite variety of form of the crania now massed together, a variety only comparable to that of leaves in a forest, this primitively simple scheme, with its four and finally six types, failed through lack of elasticity. Then began complication extending ever further and further. Attention was no longer confined to the length and breadth, but also to the height of the cranium, high and low (or flat) skulls—*i.e.*, *hypsicephalic* and *chamæcephalic* varieties being recognised. The facial part of the skull was examined not only from the side, with a view to recording the straightness or obliquity of the profile, but also from the front; and there were thus distinguished long, medium, and short faces, and also broad and narrow facial types. The nasal skeleton, the palate, the orbit, the teeth, and the mandible were investigated in turn, and at last all the individual bones of the cranium and face, their irregularities of outline, and their relations to one another, were subjected to the closest examination and most subtle measurements, with instruments of extreme delicacy of construction and ingenuity of design, till, finally, the trifling number of five thousand measurements for every skull found an advocate in the person of the Hungarian Professor v. Török (whereby the wealth of detail obscured the main objects of study); while, on the other hand, observers deviated into scientific jugglery, like that of the Italian Professor Sergi, who contrived to recognise within the limits of a single small archipelago, the D'Entrecasteaux group of islets near New Guinea, as many as eleven cranial varieties, which were all distinguished by high-sounding descriptive names, such as *Lophocephalus brachyclitometopus*, etc.'

"The misuse of Craniometry is also described by Professor Alexander Macalister: 'Despite all the labour that has been bestowed on the subject

only, and those original and important ones, are jotted down in large numbers, practically to the point of not overlooking any.¹ This method well illustrates the difference between exhaustion and subtlety.

It should be also borne in mind that, as we proceed in an enquiry, the dubious items will be either corrected or may prove relatively unimportant or irrelevant. Hence it would be unpardonable to pursue everything forthwith into the realm of the infinite, and there is scarcely any danger that we shall do this when numerous important and well-defined generalisations are the object of our quest. Subtlety, particularly in the cultural sciences, is frequently the cause that no general survey of a problem is undertaken, that only one or a few general conclusions of a somewhat indifferent character are arrived at,

craniometric literature is at present as unsatisfactory as it is dull. Hitherto observations have been concentrated on cranial measurements as methods for the discrimination of the skulls of different races. Scores of lines, arcs, chords, and indexes have been devised for this purpose, and the diagnosis of skulls has been attempted by a process as mechanical as that whereby we identify certain issues of postage-stamps by counting the nicks in the margin. But there is underlying all these no unifying hypothesis; so that when we, in our sesquipedalian jargon, describe an Australian skull as microcephalic, phænozygous, tapeinodolichocephalic, prognathic, platyrhine, hypselo-palatine, leptostaphyline, dolichuranic, chamæprosopic, and microseme, we are no nearer to the formulation of any philosophic concept of the general principles which have led to the assumption of these characters by the cranium in question, and we are forced to echo the apostrophe of von Török, *Vanity, thy name is Craniology!*" (Pp. 40-42.)

Only recently have attempts been made to study the relation of the cephalic index to the environment, with striking results. Prof. Franz Boas, of Columbia University, conducted an enquiry into this question on behalf of the United States Government, and the following is his startling conclusion: "The investigation of a large number of families has shown that every single measurement that has been studied has one value among individuals born in Europe, another one among individuals of the same families born in America. Thus, among the East European Jews, the head of the European-born is shorter than the head of the American-born. It is wider among the European-born than it is among the American-born. At the same time the American-born is taller. As a result of the increase in the growth of head, and decrease of the width of head, the length-breadth index is considerably less than the corresponding index in the European-born. All these differences seem to increase with the time elapsed between the emigration of the parents and the birth of the child, and are much more marked in the second generation of American-born individuals. . . . The old idea of absolute stability of human types must evidently be given up, and with it the belief of the hereditary superiority of certain types over others." (*Inter-Racial Problems*, pp. 101, 103, edited by G. Spiller.)

¹ Aristotle's "vast works in natural history were based mainly on what he considered of primary importance—facts of actual personal knowledge derived from personal observation. On this account alone his writings deserved the place which they held for many centuries." (A. C. Haddon, *History of Anthropology*, p. 14.) According to Sir Edward Thorpe, "Aristotle affirmed that natural science can only be founded upon a knowledge of facts, and facts can only be ascertained through observation and experiment." (*History of Chemistry*, 1914, vol. 1, p. 19.) On Aristotle's method, see also F. W. Westaway, *Scientific Method, its Philosophy and its Practice*, 1912.

and that the ultimate conclusion is neither substantiated nor verified. The employment of subtlety is principally due to the chaotic state of an unresolved general problem, for this primitive chaos suggests countless inapposite questions. A problem, like a mist, clears up imperceptibly.

All subtlety, therefore, save in respect of the final solution towards the conclusion of the investigation, is useless and mischievous, for *it is by a series of closer and closer approximations that a satisfactory solution is reached*. In this connection we ought to bear in mind that observation should be relevant and rational (§ 170), and that subtlety is often a consequence of the neglect of these two precepts. The most notable scientific practice of to-day, is for investigators to aim at resolving or developing to a certain extent some large aspect of an important problem in the light of the most general aspects, "brushing aside for a time the non-essential and rising above the confusion of detail". Triviality, completeness, dogmatism, subtlety, are eschewed.

In the preceding Conclusion we learnt that the progress of science is represented by a slow upward movement. Hence we should take it for granted in this Conclusion that any legitimate problem has its roots in other partly or entirely solved problems, and that the solution we seek restricts itself to some definite class of phenomena, and aspires to only a comparatively moderate advance. Accordingly we may affirm that, passing by general explanations concerned with groups of established sciences, the circle of scientific interest should not normally extend beyond one particular science at a time, such as geology, physiology, anthropology, or ethics.

Again, in the initial stages of an investigation it would be futile to search for momentous conclusions, for we scarcely yet know what we are inquiring into. Let it be a question of the genesis of culture, for instance. First, ethnologists should have roamed among practically all the peoples of the earth, and should have published tolerably copious notes of their customs, practices, and institutions. For the pioneer ethnologists conclusions should be of the smallest import and facts of the weightiest consequence. Yet working in the dark, as they needs must do at first, there should be no attempt to exhaust or even approach exhausting any series of phenomena. The facts of ethnography are very nearly infinite, more particularly when we contemplate the incessant changes in customs and their interpretation. Ethnographers should, therefore, be accurate and extensive in their observations, and endeavour to secure many *samples* of facts and the more common features discernible in any community. Whatever offers obstinate resistance, as the interpretation of the mentality of peoples or the ascertaining of the customs which these peoples are reluctant to divulge, they reserve for a later period. If the preliminary

investigation has been thorough, attempts to frame preliminary conclusions would be in place. In that case, however, most of the conclusions of any one worker would largely miss the mark, and investigators would construe the data according to widely varying principles. In fact, as we sought in the first stage mainly for facts, so in the second we seek for the largest number of conclusions which appear, after scrutiny, passably consistent with the facts. With weighty facts and preliminary conclusions collected, the third step may be ventured on, by probably a fresh relay of investigators, of sifting these conclusions. Lastly comes the process of consolidating and perfecting these conclusions, drawing pregnant inferences from them, and re-examining the data. Everywhere great difficulties which might needlessly absorb years of labour should be left unsolved, unless we can effect nothing without attacking these. Mere amassing of facts, formulating conclusions when the facts are yet hardly known, elaborating some single conclusion when few conclusions have been as yet obtained, should be avoided. The leading ethnographical verities will only come to the surface through the collective labours of generations of ethnographic students.

To sum up. We ascertain the more general facts and the more general conditions under which these subsist; we study the collected facts with a view to reaching a fair number of important minor and then major conclusions; we leave at first undisturbed refractory questions or solutions exacting lengthy enquiries; we further assume that familiarity with some class of fact or theory will make other classes of facts or theories appear of less moment than they seem to us; and we take it for granted that an individual's investigation of a large and new problem possesses almost certainly only partial or contributory value.

Each scholar, then, is concerned with a limited sphere of investigation, and strives to discover the largest number of the most important or most general facts and conclusions in conformity with the stage which his science or enquiry has reached. Seeing the complexity of facts, this entails continuous devotion for many years to one significant problem, and never entering more into detail than is absolutely necessitated by the circumstances. *Our leading thinkers, from Aristotle forwards, appear to have followed the rule (1) of concentrating for long periods (2) on reaching many weighty conclusions (3) in a particular subject of fair extent, (4) which is either easy of approach or where many facts have been already collected and colligated, and (5) eschewing all vagueness, subtlety, argumentation, or crude speculation as to matters obscure or unknown.*

CONCLUSION 7.

Need of recognising that Formal Rules are Barren and that Psychical Prejudice is Baneful.

§ 81. (A) *FORMAL RULES*.—The first half of this Conclusion may be dismissed with one or two remarks. As we have seen, and as we shall see (Conclusion 23), a critical attitude permeating every portion of an investigation is indispensable. A danger should, however, be guarded against—mere formal procedure. Formally to deny, or to assert the contrary of, any proposition, may even prove worse than dogmatic acquiescence in bare plausibilities. So, also, the formal piling up of, say, generalisations is to be deprecated. Our attitude should not be mechanical; we should rather weigh in each instance the merits of our doubt, of our affirmations, and so on. To call, or even to seem to call, everyone we disagree with ignorant, narrow-minded, prejudiced, unpractical, or ill-mannered, is to condemn ourselves to intellectual stagnation and inanity. Dogmatic denial is the younger brother of dogmatic affirmation.

§ 82. (B) *PSYCHICAL PREJUDICE*.—The second part of our Conclusion is far-reaching in character, for without some explanation such as we are about to tender, it would be difficult to fathom the facility and perfection with which some of the ablest minds have deceived themselves.

How otherwise could we account for a master spirit like Descartes writing to intimate friends concerning his first published work (which contained the *Discourse on Method*, together with the *Dioptric*, the *Meteors*, and the *Geometry*) "that he does not believe that there are three lines in the book which can be rejected or changed; and that if there be the least falsehood in any the least part of what he had published, his whole philosophy was not worth a straw"? (J. P. Mahaffy, *Descartes*, 1901, p. 72.) Kant, in the Introduction to his epoch-making *Kritik der reinen Vernunft*, almost repeats what Descartes affirmed of his volume. In the Preface to the first edition he states: "I make bold to say that there cannot exist a single metaphysical problem which is not here either solved or the key to the solution of which is not at least given." And in the Preface to the second edition he writes of his *magnum opus* that "any attempt to alter the least part of it would at once lead to contradictions, not only in the system but in the general human understanding". And John Stuart Mill is firm in regard to his Canons: "The four methods which it has now been attempted to describe are the only possible modes of experimental inquiry. . . . These, then, with such assistance as can be obtained from deduction, compose the available resources of the human mind for ascertaining the laws of the succession of phenomena." (*Logic*, bk. 3, ch. 8, § 7.)

The most signal example, however, of this delusion is, perhaps, Auguste Comte, one of the deepest and sincerest thinkers of modern times. In him dwelt an imperturbable faith that he had laid bare in all their essentials, and beyond the possibility of a doubt, the nature of scientific thought and the course of mankind's past, as well as the contemporary and the ultimate stages of man's progress. Although he believed that he was the first to recognise clearly the fact of human progress, he confidently sketched in minute detail the final régime, and though he placed humanity skies high above the individual, he proceeded as if henceforth nothing remained for humanity to do but to accept his explanations and to execute his schemes.

Now these four justly famous thinkers are typical exemplifications of the assurance with which, in their naïveté, philosophers generally speak, even though a study of history renders it evident that such pretensions are, to say the least, painfully exaggerated.

In the humbler sphere of observation, as we have endeavoured to show (Section III; see also Conclusion 23), we encounter the same fact. Men are convinced that they have exhausted classes of facts and conditions, when all they have often accomplished is fastidiously to pick and choose their evidence, and to misconstrue inconvenient facts where it is not possible to disregard them altogether. It is this psychological bias also which, in spite of serious contradictions in the world of experience, fortifies the believers in widely differing religious faiths.

The explanation we venture to advance is as follows. The process of thought depends on the desire to arrive at some particular conclusion.¹ When, then, we have habituated ourselves to view with favour a certain theory and to be indifferent or hostile to another—that is, when the mind is concentrated or set on a certain theory—associations connected with the favoured theory tend alone to be formed or entertained. Moreover, any stray counter-evidence will be discounted on superficial deliberation, whilst even direct observation of an embarrassing character will be materially falsified by our warped intelligence. So potent is this psychological force that a subtle special pleader may for a time compel our unwilling thought to run along his rails, and prevent us from thinking of anything which would controvert what he advances. This process grows by what it feeds on, and thus abundance of favourable evidence, of a dubious kind frequently, and scarcely any opposed thereto, however sound, comes to be stored in our minds, and hence there is artificially created a conviction of absolute certainty which, in not a few instances, is as absolutely unwarranted. Habit accentuates this tendency to

¹ G. Spiller, *The Mind of Man*, ch. 4.

partiality in such a measure that it requires the utmost effort of a generous intellect to mete out the barest justice to a new truth, and not to forget almost instantly that such a truth had been presented and sympathetically entertained. Darwin was fully aware of this. He "remarked that so easy 'is it to pass over cases that oppose a favourite generalisation, that he had made it a habit not merely to hunt for contrary instances, but also to write down any exception he noted or thought of—otherwise it was almost sure to be forgotten". (John Dewey, *How We Think*, 1910, p. 90.)

In truly scientific enquiries psychical bias occasions little havoc, because of the patent reason that trained men of science love truth and hate error very much more than any particular theory. (See, however, last paragraph of this Conclusion.) Hence the psychological mechanism favours here a correct procedure.¹ But to counteract the commonly prevailing tendency, several Conclusions have been suggested, such as 19, 23, 27, and 28, and the objective nature of the Conclusions in the aggregate is likely to defeat this partiality in all but the rarest circumstances. The synthetic and progressive character of the investigation will, moreover, generally veil the ultimate result until the time when it manifests itself unequivocally and can no longer be distorted with impunity. Furthermore, at the service of an objective inquirer, the psychological principle will perform destructive work as efficiently as constructive work, inasmuch as modifying and contradictory evidence will be searched for as zealously as evidence in support. In any case, the thinker should presuppose the pan-human origin of truth, and therefore take it for granted that, however satisfactory his results, they are yet far from being exhaustive or final.²

In the cultural sciences, philosophical, religious, economic, educational, sex, class, national, and racial prejudices and interests, more often than not effectually impede scientific advance, men undertaking to prove or to disprove certain theories because these appeal to them or because they are repelled by them. In industry and commerce the yoke of mechanical routine and narrow self-interest equally obstructs progress. In most of these instances, the brain-twisting bias is unsuspected by the theoriser, and nothing almost will move

¹ "When once we have decided what we will think about, we must think with perfect impartiality on both sides." (Mrs. Boole, *Logic Taught by Love*, p. 71.) Darwin went even further, and always used the isolated phenomena which were most difficult to explain as tests of the validity of his hypotheses. (Frank Cramer, *op. cit.*, p. 230.)

² "The chief sources of prejudices are: Imitation, Custom, and Inclination." (Kant, *Introduction to Logic*, p. 66.) Ribot discusses the relation of the feelings to logic in his *La logique des sentiments*, Paris, 1905. See also Victor Brochard, *De l'erreur*, 1879.

him to look truth straight in the face. Fortunately, however, there is a growing feeling that the love of truth should be the supreme arbiter in all enquiries, and that, especially in social investigations, antipathy is the sworn foe of truth, and narrow sympathy scarcely less. Were it not for psychical prejudice selecting favourable, and ignoring or rejecting unfavourable, evidence, this wholesale and consummate self-deception would be impossible.¹

We have dilated above on a familiar form of prejudiced thinking. Delving deeper, we encounter another and more insidious form, which makes its home in the scientific process itself. That is, the material we have collected and the conclusions we have arrived at, psychologically fill, and therefore dominate, our minds, and we accordingly neither perceive things in perspective nor as others would view them. The remedy for this is a two-fold one. We should periodically suspend our studies for appreciable periods at a time. This would lead to a scattering of the mass of familiar but unimportant ideas and divest those ideas of much of their feeling value. We should consequently be able to assume a more critical and objective attitude towards our studies, and correct prejudiced conclusions. (See § 161.) Moreover, throughout our scientific work we should cultivate the detachment and coolness of the critic who comes fresh to an examination of our views. We should therefore be habituated to see ourselves, from time to time, as others see us. Unless we acquire this rare capacity, together with the self-control needed in occasionally interrupting our labours for appreciable periods, we are in perennial danger of reaching sophisticated results.

¹ "The information which an ordinary traveller brings back from a foreign country, as the result of the evidence of his senses, is almost always such as exactly confirms the opinions with which he sets out. He has had eyes and ears for such things only as he expected to see. Men read the sacred books of their religion, and pass unobserved therein multitudes of things utterly irreconcilable with even their own notions of moral excellence. With the same authorities before them, different historians, alike innocent of intentional misrepresentation, see only what is favourable to Protestants or Catholics, Royalists or Republicans, Charles I. or Cromwell; while others, having set out with the preconception that extremes must be in the wrong, are incapable of seeing truth and justice when these are wholly on one side." (Mill, *Logic*, bk. 5, ch. 4, § 3.) "Before experience itself can be used with advantage, there is one preliminary step to make, which depends wholly on ourselves: it is the absolute dismissal and clearing the mind of all prejudice, from whatever source arising, and the determination to stand and fall by the result of a direct appeal to facts in the first instance, and of strict logical deduction from them afterwards." (Herschel, *Discourse*, [68].)

"The temptations to make statements too broad, to neglect objections, to smooth over difficulties artificially, are almost infinite." (Frank Cramer, *op. cit.*, p. 31.)

CONCLUSION 8.

Need of taking advantage of Special Scientific Methods, of utilising Existing Knowledge, of having regard to the Future, and of allowing for Personal Equation and for Training.

§ 83. (A) *RECOGNISED SCIENTIFIC METHODS*.—The following methods are among those generally applied: (a) Approaching the remote and unknown from the side of the known and near, including analogy, as in geology and history; (b) proceeding by the law of probability, of approximation, or of averages, as in the social and anthropological sciences; (c) applying the comparative method, as in zoology, therapeutics, and psychology, and quite generally the geographical method, that is, allowing for possible factual differences to be found in different localities; (d) employing separately or together the historical, the genetic, and the evolutionary methods, as in biological, economic, æsthetic, and many other kinds of investigations; (e) using the teleological method, as in ethics, or in botany—*e.g.*, the adaptation of flowers to pollen-carrying insects; (f) approaching the complex and abstract from the side of the simple and concrete, as illustrated by diagrammatic procedure and in Conclusion 19; and (g) imagining ideally simplified instances, as in astronomy or mechanics. According to circumstances, as many of these methods as possible should be employed in an enquiry. Of capital importance are (c) and (d). In connection with (d) it should be remembered that, if sufficiently brief or extensive periods are allowed for, time almost always makes a crucial difference, and in this respect it is advisable to extend the criterion to the future as well as to the past and present—to infinity backwards and forwards,¹ so far as the largest problems are concerned. All these methods are treated by implication in the subsequent Conclusions, and are, as above intimated, individually more applicable to one department of knowledge than to another.

A treacherous method is undoubtedly that of analogy.² Let us provide a modern instance of this. Darwin repeatedly compared the “intelligence” of animals with the intelligence of human beings, and from his day to ours these comparisons

¹ “The student who takes an equal interest in the history of the past, the development of the present, and the destinies of the future, keeps his mind balanced.” (Mary E. Boole, *Logic Taught by Love*, p. 160.)

² “An argument from analogy is an inference that what is true in a certain case is true in a case known to be somewhat similar, but not known to be exactly parallel, that is, to be similar in all the material circumstances.” (Mill, *Logic*, bk. 5, ch. 5, § 6.) We should sharply distinguish analogies from homologies. The latter are of considerable moment in science, *e.g.*, interminable homologies of structure have been discovered in the domain of biology, and the sciences of heat, light, and electricity, are homologous so far as undulatory motion and velocity of transmission are concerned. The comparative method, as in reasoning from animals to man, occupies an intermediate position, and requires scrupulous checking.

have flourished. Yet there is here no real analogy. If, for example, we desire to know what a lump of ore is composed of, we conduct a variety of complicated experiments; but inasmuch as the mode of our procedure in this case is the outcome of æons of inventions and discoveries *traditionally* preserved, the detailed examination of our procedure tells us nothing in regard to our *inborn* "intelligence". To ascertain the latter, we ought to examine an individual entirely without education, or think of the "intelligence" of man before he acquired the rudiments of culture. For the same reason, experiments on animals which seek to elicit their mental capacity, are misleading if they are based on the supposition that all animal species have the same wants, interests, or capacities as man. In such experiments we should allot to each animal species its own proper tasks, and decline to be deceived by vague analogies.

In the life of practice, however, when inventiveness or resourcefulness are desirable, analogical reasoning is of some value. Yet here also we should beware of dubious analogies, such as the following one where different species and distinct breeds are compared to a chance collection of human individuals forming generally neither separate species nor distinct breeds: "Suppose a contractor had in his stable a miscellaneous collection of draft animals, including small donkeys, ponies, light horses, carriage horses, and fine dray horses, and a law were to be made that no animal in the stable should be allowed to do more than 'a fair day's work' for a donkey. The injustice of such a law would be apparent to every one. . . . And the difference between the first-class men and the poor ones is quite as great as that between fine dray horses and donkeys." (F. W. Taylor, *Shop Management*, p. 189.) As Davy stated: "Analogy is the fruitful parent of error."

§ 84. (B) UTILISATION OF EXISTING KNOWLEDGE.—There is considerable room for utilising knowledge acquired in the past, which knowledge may be roughly said to fall within five categories:

(a) General knowledge, such as *this* suggesting *that*; *one*, many, all; *beginning*, middle, end; *rise*, fall; *yes*, no; *infant*, child, adolescent, adult; and all most widely recognised relations and facts. Whilst criticism should be unsparing here, it must be tempered by the recollection that this kind of elemental knowledge enshrines the foundation of all the sciences, man's first and greatest effort to think humanly.¹

¹ "The child growing up learns, along with the vocables of his mother tongue, that things which he would have believed to be different are, in important points, the same. Without any formal instruction, the language in which we grow up teaches us all the common philosophy of the age. It directs us to observe and know things which we should have overlooked; it supplies us with classifications ready made, by which things are arranged (as far as the light of bygone generations admits) with the objects to which

(b) Knowledge of a concrete and a less universal character, such as that embodied in science generally and in methodology. Not only is a thorough grounding in the principal sciences indispensable to him who desires to pursue any science in particular, but he must keep in touch with new discoveries. Unless he compasses the former, he is almost certain to produce second-rate work, lacking as he does the generous background for all thorough researches which is so conspicuously present in our best thinkers; and unless he attempts the latter, his knowledge will not only be antiquated but will become to some extent useless through being, if not forgotten, imperfectly related to the latest phases of development. For this reason the specialist cannot be too particular in keeping abreast of the knowledge of his time. What he loses thereby, will be amply compensated by the stimulus and assistance he will receive. Narrow concentration is unmethodological, and leads to over-specialisation and to trivial generalisations. The harmonious development and interaction of all the sciences and arts can only be secured by each specialist having a regard and a care for the whole; and, in fact, *the ablest specialists are precisely those whose sweep of interests recognises no limits.* The possession of extensive and up-to-date knowledge of scientific and other data, should be therefore presupposed in all scientific inquirers.

(c) Knowledge more especially of those sciences which have a more or less close bearing on the subject of our investigations. After what we have stated under (b), this is too manifest to need elaborating. If we take a provincial view of our theme, we are likely to miss its profounder implications. Any one, for instance, interested in any of the cultural sciences—*e.g.*, anthropology, psychology, education, æsthetics, ethics, economics, law, politics—should be to a certain extent interested in all, and in his own department seek to do justice to each of them. Owing to the scanty store of sifted knowledge in the past, there was once a legitimate tendency to pay little attention to all but an infinitesimal arc of a subject; but with the impressive growth of that store, the methodological demand becomes more and more insistent that the specialist's horizon should be as extended as circumstances permit. (See § 73.)

(d) Knowledge of the special subject investigated, whence many suggestions may be derived. This knowledge is vital, since the vast aggregate of relatively valid generalisations and observations traceable to others requires to be fitted into the structure of our own results. Unless therefore we are familiar with our subject as known in our day, we are likely to squander much time in arriving at conclusions already established, and

they bear the greatest total resemblance. The number of general names in a language, and the degree of generality of those names, afford a test of the knowledge of the era and of the intellectual insight which is the birthright of any one born into it." (Bain, quoted by Mill, *Logic*, bk. 4, ch. 3, § 1.)

miss the stimulus of intimate acquaintance with the trials and labours of others in an analogous position to ourselves.

(e) The finished product is of comparatively trifling significance in furnishing an insight into the origin or origination of the sciences, an aspect of decisive importance for the man of science who aspires to be a discoverer. Accordingly, the study of older works and the study of the history of the sciences and arts should be assiduously cultivated. Knowledge of antiquity and antiquity of knowledge are indispensable.

(f) Comte made out a plausible case for an inter-specialist science, a science which would act as a bond and intermediary between all the sciences. In a certain sense—as illustrated even by the scope of this work—his was a reasonable demand. Nevertheless, when we remember that narrow specialisation grows more and more anti-scientific as sound knowledge accumulates; that there are now various groups of closely related sciences; that it is difficult to harmonise or generalise without experience and verification; and that the true scholar is encyclopædic in his understanding of phenomena, it will be seen that an inter-specialist science has limited possibilities. Indeed, if the proposal of such a science should tend towards an intensification of specialisation, its effect on progress would be prejudicial in the extreme. We conclude therefore that the scholarly specialist will probably overlook little that is relevant in the learning of his day, and that what is additionally needed is a wide interest in science as such, in order to ensure that a sufficient number of scientific works of a comprehensive character is produced. These would aim both at pointing out certain blanks in our knowledge, and intimate how the sciences of the day might be conveniently blended into a comparatively connected whole. If there has to be a choice, it is far more important that the investigator shall have breadth of knowledge than that he shall, relatively or absolutely, exhaust the specialist literature.

Inasmuch as our more prominent thinkers are almost invariably instructors in higher educational establishments, and seeing that the scope of their duties is decided for them by their governors whose interest cannot be solely that of research, it may be contended that little can be attained in practice to satisfy methodological demands. Consequently, it may be argued that most of our academic teachers are compelled to take for their province a whole series of sciences, whilst others are required to specialise to a high degree, and all are expected to read prodigiously. Even under such unfavourable conditions, however, much might be achieved. The teacher of philosophy, for instance, who lectures on metaphysics, logics, ethics, and æsthetics, may still devote a certain time to exploring thoroughly *one* of these sciences, and his specialist colleague who lectures on thermodynamics may engage on the converse task of grappling with some large problem, say the properties of matter. Needless to remark, this labour of love, pursued throughout a life-time, will exert an extremely vitalising and beneficent influence on the official outpourings of the two types of teachers.

The above objection appears at first sight almost completely fatal in the economic life where every moment of a long day is supposed to be

devoted to visible results. This, however, is being progressively met by trades and firms having research departments and re-organisers, and by so arranging the duties of certain individuals that they may have, when required, ample leisure to experiment and to think of ordinary and radical improvements.

In any investigation the present Sub-Conclusion plays manifestly a weighty part, for unless we consult our contemporaries and the past, steady advance in an enquiry is sadly hampered.¹

§ 85. (C) *REGARD FOR THE FUTURE*.—To ensure a true perspective we should also pay heed to the demands of posterity. Only when our vision extends to the future, are we likely to gain a comprehensive view of our subject and be sufficiently bold in our aspirations and conceptions.

§ 86. (D) *PERSONAL EQUATION AND TRAINING*.—We naturally do not postulate in this treatise that everybody can equally well undertake the solution of any and every problem after a perusal of the Conclusions submitted in these pages. There should be some guidance and practice initially, and a fair general education to serve as a basis. We should, in the second place, select a class of problem already under investigation (Conclusion 5), and enter on a discriminating study of what has been hitherto accomplished rather than be entirely ruled by abstract notions. Such a study, continued throughout the enquiry, will act both as a check and as a spur. We manifestly should, thirdly, make a direct and general survey of our subject before actually launching our enquiry. Next arises the point of our suitability for the task selected. Persons with relatively inadequate preparation, time, and resources should preferably select scientific work which accords with their limitations, and these will concentrate on comparatively restricted issues, or assist others.² The varying personal equation, the need for training, and the financial and other support tendered to scientific institutions or to men of science are, therefore, presupposed throughout these pages.

¹ Without pretending to prescribe a course of reading, it may be pointed out that the main conclusions in most departments of knowledge may be found in comprehensive text-books, or even primers, written by competent specialists, and that encyclopædias and excellent manuals on physiography, biology, etc., epitomise the contents of related sciences. There is therefore no need to read every book on every subject in order to be passably well-informed.

² "There is scarcely any well-informed person, who, if he has but the will, has not also the power to add something essential to the general stock of knowledge, if he will only observe regularly and methodically some particular class of facts which may most excite his attention, or which his situation may best enable him to study with effect." (Herschel, *Discourse*, [127.].) In the vocational life, for example, few are so unfavourably situated that they cannot make and suggest improvements in their particular sphere. Even if each one were only to perform his or her task conscientiously and intelligently, the life of mankind would be revolutionised.

Here are a few detailed injunctions relating to self-training at all periods of life:—

- (a) Follow precedent, follow the best precedents;
- (b) Follow example, follow the best examples;
- (c) Learn by the experience of others, learn by your own experience;
- (d) Inquire of, and consult with, others;
- (e) Profit by what is revealed by accident or special circumstances;
- (f) Learn through appropriate, and increasingly profounder, reading and study;
- (g) Learn through frequently, and sometimes systematically, reflecting over work, its minor and major problems, with a view to its improvement;
- (h) Experiment both on a limited and on an extensive scale;
- (i) Seek to improve on, and generalise as widely as possible, what you have learnt through precedent, example, experience, enquiry and consultation, accident and special circumstances, reading and study, frequent and also systematic reflection, and experiments; and
- (j) Continue all your life improving methods and products by the above and by other means.

CONCLUSION 9.

Need of Experimental Preparation in Methodology.

§ 87. The habit of methodical scientific procedure, a habit than which it would be difficult to conceive one more important to acquire, should be easily attainable by the student.

Consider the problem of generalisation. At the lowest stage of training this would require habitual generalising as such. To acquire this art, the student might proceed as follows. Sitting in a room, he may, following the principle embodied in Conclusion 25, generalise everything he sees or hears. Thus "It would be well if every sitting-room everywhere had a table, had chairs, had a sofa, had pictures, had maps, had a globe, had books, had wall paper, had central heating, had a carpet, had rugs, had a door, had windows, had electric light, had a clock, had ornaments", and so on with every object in the room, and also with any sounds, such as that of the tickings of the clock. This process may be repeated with every part of the building, and may be then continued, on a monster scale, with the world as revealed by tours round the town and country and by examining the various senses and the furniture of the mind. No doubt, before everything observed had been generalised in this crude way, the student will be obsessed by the desire to generalise everything. After this, we may particularise intensively before generalising. The table, that is, becomes a specific kind of table, and so with the chairs, and with all other

objects noted. Finally, each of the minutest features of the table, etc., will offer further points of departure for generalising.

We have reached the second stage. Observing, for instance, a notice relating to fares in an omnibus, the student generalises to all omnibuses, then to tramcars, to other vehicles plying for hire, to railways, and to craft for water and air. He further generalises, *in detail*, to all possible places, like theatres, where prices might be affixed in a convenient situation. He then generalises, *also in detail*, the idea of notices on any topic being posted in all private and public places all over the world where such notices might prove advantageous. He proceeds further and extends, *in detail*, the term notice to any statement be it spoken, written, printed, engraved, tabular, diagrammatic, symbolical, or otherwise. Having attained his end thus far, he resumes his experimental practice by noting one after another the innumerable constituent features of the omnibus and then of other objects or of events, and treats them as he treated the omnibus notice relating to omnibus fares. This also satisfactorily disposed of, he commences to particularise, generalising, say, the many aspects of the notice-board—its material, its size, its shape, its colour, its letters and figures, its total content, its position in the omnibus, and so forth, and passes in this way from object to object and from event to event.

We envisage now the third stage—strictly methodical generalisation. Here we proceed as in the second stage, save that we act methodically. That is, if it be the notice relating to fares in the omnibus, the moment we think of generalising this matter, we imagine the humblest and shabbiest vehicle, and cautiously and methodically continue to apply the generalisation until we picture to ourselves the most gigantic and most sumptuously furnished ocean liner. We then resume as methodically, but this time in a methodical order, all the other lines of enquiry intimated or implied in the preceding paragraph.

Only one further step is needed to complete the methodological training, and this is to convert the aimless and indiscriminate generalising into purposeful and discriminating generalising. That is, returning again to the notice-board, we judge how far and to what extent the notice particularising fares is justified in the given omnibus at the given time, and how far we may profitably generalise this particular mode of communicating information. Repeating, on this higher plane, what has been attempted on lower planes, there is every likelihood that numerous valid and valuable generalisations will be obtained.

Thus we learn that the habit of methodical generalising can be readily acquired, and, by implication, that if men commonly generalise sporadically and unmethodically, this is most probably incidental to the absence of appropriate training.

Needless to state that the procedure proposed in connection with generalising should be also pursued in respect of all the

mental processes dwelt on in the series of thirty-six Conclusions. Once methodology becomes a recognised science, experimental methodological training of a methodical character, under the supervision of trained teachers, will be universal. That is, the student of methodology will not only strive to comprehend and memorise certain propositions, but he will undergo a course of experimental training.

CONCLUSION 10.

Need of securing the Mental, Physiological, and Environmental Conditions conducive to Efficiency and to Waste Elimination.

§ 88. Throughout our discussions in this treatise our minds have been, and will be, almost exclusively concentrated on the impersonal methodological means whereby our objective methodological goal is to be reached. Seek truth, we urge, and do this by scrupulous attention to certain conclusions which have been, or which may be, formulated. First, we aver, ascertain the precise nature of the problem to be investigated, then examine the facts according to certain scientific canons, and so forth. In each of these cases we may enter into minute detail; but throughout we remain on the objective plane, advising what every one should do who is in quest of truth and ignoring circumstances foreign to this objective standpoint.

In brief, we are assuming throughout that we are psychological and physiological automata, uninfluenced by anything save inclination or aversion to truth. Of course, men presuppose that insanity or serious indisposition will detrimentally affect efficiency; but they also tacitly postulate that in the case of what is called the normal individual the functioning of the mind and body is virtually invariable and perfect.

Yet this is very far from being true. Haphazard movements of the mind and body, unnecessary slowness, uneconomical use of energies, overwork or unintelligent work resulting in paralysing fatigue, ill adapted instruments, materials, and surroundings generally, contribute towards sensibly depreciating the quantity and the quality of work. Disregard of these and analogous pre-requisites will result in an output markedly poorer in every respect than that attained when the attendant non-methodological circumstances are favourable.

Accordingly, we shall endeavour to formulate the general conditions conducive to efficiency, comprehending every type of labour.¹

Assuming output of high quality as the end, ideal economy in its production will be achieved by securing the mental,

¹ An essentially popular and able treatment of the subject will be found in *Le travail intellectuel et la volonté*, by Jules Payot, Paris, 1920.—“Pelmanism” is the name of a present-day system of mind-training recommended by many literary and other notabilities.

physiological, and environmental conditions favouring efficient performance. As will be seen, such economy will furnish products of a standard quality, and will therefore make towards uniformly high quality as well as towards great quantity. The problem of systematically improving what is given, which is the complement to economy, is dealt with in § 171, since this forms an integral part of objective methodology.

The basic reconstruction of scientific, artistic, administrative, professional, educational, economic, domestic, and other mental and bodily activities—with a view to maximum output of optimum quality in minimum time with least effort and with no avoidable depreciation or waste¹ of instruments, materials, and material and mental energies, congruent with a long, rich, worthy, and joyous life, involves the following factors:—

§ 89.—1. *ECONOMY OF PURPOSE*.—(a) The aiming at unambiguity or clearness, of distinctness or decided distinctiveness, and of conspicuousness or ready apprehensibility, of purpose or of the conception of the task to be realised.

(b) The application of the above to the purposes subsidiary to the initial purpose.

2. *ECONOMY OF VOLITION*.—(a) The unhesitating translation of the above purpose into the appropriate act, involving maybe courage, resoluteness, strenuousness, and the resolve to be persevering and adaptable.

(b) The application of a volition subsidiary to the initial volition, including, besides independence of thought and judgment, quickness of decision, initiative, originality, enterprise, and forethought. (The elements of these qualities require to be ascertained and recorded in detail.)

¹ The question of the conservation of natural products, such as coal, metals, forests, and countless others, merits the close attention of the economist and the statesman. Not until we have harnessed the energies of the ocean tides, of the sun, or of the atom to our engines, and have realised by science the ambitions of the alchemists of old, shall we be justified in lavishly consuming nature's wealth. *E.g.*, "if it were possible to convert the chemical energy of coal completely into work, without at first burning it to liberate the energy as heat, the energy of 1 ton of coal would then be sufficient to lift one of the largest liners, weighing 20,000 tons, 500 feet high." (F. Soddy, *Matter and Energy*, p. 31.) Indeed, as our methodology compels us to take into account the distant future, we have seriously, though without alarm, to ask ourselves whether our remote descendants will know anything of precious or useful metals, of material fuels and non-artificial fertilisers, of natural precious stones, of wild, or even domesticated, animals, of natural scenery, and much else that we find in the bowels or on the surface of the earth, not excluding the moral, intellectual, artistic, and historic treasures of the then hoary past. A less remote contingency is the elimination of the vast stretches of waste in our present economic system. To the diverse aspects dealt with in this Conclusion, we may add organisation for mass production and distribution, introduction wherever possible of automatic labour-saving machinery, national and international organisation of transport and power facilities, exclusion of unnecessary middlemen, and elimination of anti-social methods in the conduct of undertakings.

(c) The methodical perfecting of the volitional powers.

3. *ECONOMY OF SENSATIONS*.—Consequent on willing, *where a material act is to be performed*, (a) the rapid recognition and delicate and swift discrimination of the sensory material offered.

(b) The application of the above to the sensings which succeed the initiating sensations at intervals.

(c) The careful education of at least the senses of sight, hearing, and touch, in order to ensure the above.

(d) The favouring of neatness (or clearness), conspicuousness, and distinctness (or decided separateness), in physical activities generally (*e.g.*, in writing), with a view to facilitating sensory recognition and discrimination.

4. *ECONOMY OF MEMORY*.—Consequent on willing, *where a mental act is to be performed*, (a) instantaneous and correct recollection or recognition of the mental movements contemplated.

(b) Application of the above to the memory processes succeeding the initiating recollections and recognitions; and, in order to ensure their efficiency,

(c) The acquisition through training of a good general memory—comprehensive, durable, ordered, reliable, and responsive;

(d) The acquisition of a good task memory for at least brief periods (days or weeks), of a broad-span memory for briefest periods (seconds or minutes), and the systematic and faultless memorising of frequently recurring movements, facts, and figures;

(e) Methodical and long-continued practice to ensure instantaneous and correct recollection at the appropriate moment—mental, sensory, muscular—of everything habitual relating to a task; and

(f) The favouring of neatness (or clearness), conspicuousness, and distinctness (or decided separateness), in observation and thought in order to facilitate retention, recognition, and recollection.

5. *ECONOMY OF MOVEMENTS*.—The theoretical aim should be, ideally speaking, to complete a whole task with a single, scarcely perceptible, continuous movement.

(a) The elimination of superfluous movements and operations.

(b) The substitution, wherever practicable, of a continuous movement for a series of movements.

(c) The substitution, wherever practicable, of combined for successive movements and operations (*e.g.*, employing simultaneously, so far as practicable, both hands, every finger, the limbs, etc., for separate operations).

(d) The utilisation of instruments (tray, note-book, generalisation, utilising an errand for several objects instead of one, etc.), so as to minimise movements.

(e) Arranging any series of movements with due regard to their easily fitting into one another.

(f) The elimination of circuitous, haphazard, false, and non-standardised movements.

(g) The maximum contraction of movements.

(h) Insofar as practicable, the omission or drastic simplification or abbreviation of anything frequently recurring.

(i) The deliberate and methodical elimination from each new or old task of everything which can be dispensed with.

(j) The encouragement of initial accuracy, leading as it does to an extensive reduction of superfluous movements. (§ 124.)

(k) Paying special attention to the larger and more important aspects, since these render redundant much detail.

(l) The replacing, where possible, of human labour by labour-saving appliances.

(m) Such a spatial distribution of individuals, groups, departments, furniture, and materials as shall contribute to the most economical collaboration in collective tasks.

(n) The establishment of a standardised and completely recorded series of movements for tasks and part tasks, and strict adherence thereto.

(o) The provision for a periodical re-adaptation and improvement of standards.

6. *ECONOMY OF TIME IN MOVEMENTS*.—The theoretical aim should be to complete the movements necessary within an infinitesimal period of time.

(a) The determination of the average maximum speed practicable for normal and exceptional individuals and circumstances.

(b) The maximum acceleration of movements.

(c) The selection of movements, and movement complexes, which allow of highest speeds.

(d) The elimination, insofar as practicable, of (*e.g.*, cumbrous) movements which are inconsistent with highest speeds.

(e) The removal of impediments to fullest freedom in movement.

(f) The encouragement of rapid rhythmic movements.

(g) Methodical practice to accelerate speed.

(h) The elimination, or maximal contraction, of pauses between movements and operations.

(i) Methodical practice to eliminate, or maximally reduce, pauses.

(j) The systematic utilisation of unavoidable pauses and partially free mental energies.

(k) Planning a contemplated task, or part task, whilst engaged on another.

(l) So organising the work that it can proceed without delays, disturbances, and shorter or longer interruptions.

(m) Perennial alertness, without being engrossed in one particular.

(n) The aiming at neatness (or clearness), conspicuousness, and distinctness (or decided separateness), in every type of mental and physical task, as favouring speed.

(o) The application of a trained intelligence to the expeditious solution of difficulties.

(p) Having instruments and materials, of an appropriate and sterling character and in good condition, always ready to hand, and having products systematically removed.

(q) Proper co-ordination, and hearty co-operation and collaboration, of individuals, groups, and departments, engaged on a particular task or related tasks.

(r) The keeping down of fatigue to a level consistent with the maintenance of a uniformly high hourly and daily average speed. (See 7.)

(s) The establishment of an absolute and an average time standard for a task and for parts thereof, and strict adherence thereto.

(t) The provision for a periodical re-adaptation and improvement of standards.

7. *ECONOMY OF EFFORT AND FATIGUE IN MOVEMENTS*.—The theoretical aim should be to complete the movements necessary for an operation with the expenditure of an infinitesimal degree of effort and with a negligible amount of fatigue.

(a) The determination of the average maximum effort practicable for normal and exceptional individuals and circumstances.

(b) The elimination of superfluous exertions.

(c) The increase of exertions, where needed, to the maximum limit consistent with hygienic or quickly removed fatigue—that is, fatigue which does not reduce quantity or quality of work, which does not leave the individual very tired after working hours, and which permits of complete recuperation by the following morning.

(d) The determination of the maximum average exertion consistent with hygienic or quickly removed fatigue.

(e) The distribution of exertions over several organs and in the least fatiguing order.

(f) The allocation of movements to organs and muscles best able to produce them with least effort and least fatigue.

(g) The introduction, wherever practicable, of rhythms in movements.

(h) Methodical practice to raise the individual's power and endurance.

(i) The elimination of unnecessary fatiguing movements (excluding, as far as practicable, bending, stooping, turning, twisting, and extended arm work).

(j) The encouragement of a bearing and gait, as well as of bodily proportions, and also of garments, conducive to maximum exertion and minimum fatigue.

(*k*) The re-arrangement of tasks and parts thereof, of the hours and time-of-day of work, of meal-times, of rest-accessories, of rest-periods within and outside working-hours, of recreation, of daily hours of labour, of week-end pauses and holidays, with the object of minimising debilitating fatigue and maintaining mental and bodily vigour.

(*l*) The establishment of proper indoor or outdoor conditions—(1) pure air, avoidance of cold and heat, good light by day and night, satisfactory rest room, canteen, mess room, committee room, cloak room, and lavatory accommodation, effective dusting and cleaning, provisions for first-aid, modern sanitary arrangements and other conveniences, comparative silence, protection from avoidable disturbance or interference, regard for æsthetic sense; and (2) equitable and courteous treatment by superiors.

(*m*) The eschewing of noxious foods, beverages, narcotics, and amusements, and of deleterious habits generally.

(*n*) The corresponding promotion of the proper functioning of the respiratory, alimentary, circulatory, muscular, nervous and neural systems, and of robust mental and bodily health generally.

(*o*) The avoidance of nervousness, excitement, and pain, inasmuch as these tend to depress energy and intensify fatigue.

(*p*) The existence of an interest and pleasure in the task and pursuit.

(*q*) The recognition of the high hygienic and happiness value of strenuousness, and of the detrimental effect on health and happiness of idleness or slacking.

(*r*) Love of work, a cheerful, buoyant spirit, and equanimity and kindly disposition.

(*s*) Genial colleagues.

(*t*) Security of post, and adequate provision for self and family for the present, for old age, and for all contingencies.

(*u*) Ample opportunities, and full liberty, to participate in the bracing larger life beyond the particular pursuit.

(*v*) The establishment of an average standard, or of average standards, for maximum effort and maximum fatigue consistent with the maintenance of robust health.

(*w*) The provision for a periodical re-adaptation and improvement of standards.

8. *ECONOMY OF THOUGHT AND FEELING*.—The theoretical aim should be to complete the necessary movements with a minimum of cogitation and feeling.

(*a*) A sound general education as a solid basis for efficiency in a particular avocation, and a sound body (involving proper nourishment, etc.) as a necessary basis for a sound education.

(*b*) The thorough early training in the particular pursuit, by trained instructors who are acquainted with the best methods of work and teaching, and the possession of the fullest up-to-date information directly or indirectly germane thereto.

(c) Methodical practice in order to grow increasingly proficient in economising thought and feeling.

(d) The perfecting of the capacity to observe, of the reasoning process, of the judgment, of the imagination, of the æsthetic sense, of the desire to do one's duty, and of general manipulative dexterity, mental and bodily.

(e) The encouragement of initial accuracy (§ 124), resourcefulness (§ 135), and self-training (§ 86).

(f) The creation of pauses for critically reviewing the past, planning the future, and thinking out well and at leisure complicated tasks. (In large undertakings this would entail instituting a planning, a progress, and a costing department.)

(g) The calculation of everything practicable by measurement or mathematically, or at least arriving at quite definite, methodical, and durable decisions or arrangements.

(h) The classification, and the subsequent separation and standardisation, of procedures, materials, etc., and the elimination of unnecessary diversity.

(i) The generalising, and the deductive, exploitation of what proves advantageous.

(j) The systematic specialisation of functions and subdivision of tasks with the object of enhancing productivity (and quality), allowing for fair insight into connected functions and tasks.

(k) The improvement and development of given processes and products, the striking out along new profitable lines, and the discouragement of mere routine and sheer love-of-change, as all but the supreme duty of the worker. (See § 171.)

(l) The evolution of a temperament and of emotional attitudes stimulating and not depressing activity—*e.g.*, equanimity, quiet cheerfulness, friendly feelings towards others, trustfulness.

(m) The establishment of an average general standard of intelligence and feelings for (a) pursuits and for (b) tasks.

(n) The provision for a periodical re-adaptation and improvement of standards.

9. *ECONOMY OF LOCALITY, ACCOMMODATION, FURNITURE, INSTRUMENTS, MATERIALS, MACHINERY, AND MATERIAL ENERGIES.*—(a) The close adaptation of these to the peculiarities and possibilities of the mind and body, as set out in 1 to 8 above.

(b) The avoidance of depreciation and waste in the above.

10. *ECONOMY OF PRODUCTS.*—(a) The creation of such products only as tend to promote the lasting welfare of the individual, the community, and mankind—*i.e.*, as tend to realise the good, the true, the hygienic, and the beautiful.

(b) The creation of products of the highest quality only, as being most economical.

(c) The avoidance of depreciation and waste of products.

11. *ECONOMY OF INDIVIDUAL ACTION.*—(a) Systematic and radical co-ordination of life and related pursuits—and of

pursuits generally in a hierarchical order—locally, nationally, and internationally, in order to increase productivity and diminish waste.

(b) The widest dissemination and standardisation of what is found to be of value.

12. *SUMMARY*.—The radical reconstruction of processes and procedures in order maximally to economise purpose, volition, sensations, memory, and, more especially, (a) movements as such, (b) time in movements, (c) effort and fatigue in movements, (d) thought and feeling in movements, (e) locality, accommodation, furniture, instruments, materials, machinery, and material energies, (f) products, and (g) individual action.

Basic Reconstruction.—Real economy implies basic reconstruction. "It is as well to recognise first as last that real progress from the best present method to the standard method can never be made solely by elimination. The sooner this is recognised the better. Elimination is often an admirable makeshift. But the only real progress comes through a reconstruction of the operation, building it up of standardised units, or elements." (F. B. Gilbreth, *Motion Study*, 1911, p. 91.)

As might be anticipated, basic reconstruction absorbs much time. "Mr. Gantt says that the setting of each of his tasks meant at least a year's preliminary work at a time—and motion-study, general or special, and in some cases two years." (M. and H. D. McKillop, *Efficiency Methods*, 1917, p. 107.)

Motion-Study.—"Motion study has been described as the dividing of the elements of the work into the most elementary subdivisions possible, studying and measuring the variables of these fundamental units separately and in relation to one another, and from these studied, chosen units, after they have been derived, building up methods of least waste." (Frank B. and Lillian M. Gilbreth, *Fatigue Study*, 1919, p. 11.)

Motion study is largely instrumental. "The methods of measurement of activity are motion study, micromotion study, the cyclegraph, the chronocyclegraph, and the penetrating screen." (*Ibid.*, p. 131.)

Here is an example of concrete motion study. "Gilbreth found that with the customary way of laying bricks eighteen motions were employed in laying a single brick, but eleven of these could be omitted altogether, and some of the others could be combined, so that the required motions were reduced to one and three-quarters." (Frederick S. Lee, *The Human Machine and Industrial Efficiency*, 1918, pp. 19-20.)

FATIGUE.—"Fatigue study is related to motion study in that both are branches of waste elimination." (Frank B. and Lillian M. Gilbreth, *Fatigue Study*, p. 17.)

"Even where fatigue is not materially cut down during working hours, because measurement shows that the worker is not getting over-fatigued, the general health is apt to improve because of greater regularity in habits of work, and because of better physical and mental habits while doing the work. The path along this line is a continuous, never-ending upward spiral. Fatigue is eliminated by establishing proper habits. The proper habits improve health. The improved health allows of more work with less fatigue, etc." (*Ibid.*, p. 143.) "At any stage in the process of fatigue elimination the results may be tested. The general health of the worker, his prolonged activity, his posture, his behaviour, act as such tests." (*Ibid.*, p. 151.)

It is usually the tired motorman who has the collision. The tired locomotive engineer passes the stop signal. The exhausted motorist is in the accident. The tired operator gets his fingers caught in the machine. The overtired sickroom attendant gives the wrong medicine." (*Ibid.*, p. 86.)

The first classic on the subject of fatigue is *Industrial Health and Efficiency*, being the Final Report of the Health of Munition Workers Committee of the British Ministry of Munitions. The volume shows that only short hours of work are consistent with health and with large output.

HABIT.—We must allow for the gradual manner in which new habits are acquired. "An operation took on an average 2.17 minutes. After the method had been modified, the worker took 1.6 minutes. In a short time she took only 0.5 minutes." (M. and A. D. McKillop, *Efficiency Methods*, p. 110.)

HOURS OF LABOUR.—The effect of reducing the number of hours worked is sometimes startling. "I should like to quote an instance, occurring recently in a surgical dressing factory where women were engaged as yarn-winders, an occupation requiring much dexterity and the constant repairing of broken threads. The daily hours of work were ten, namely from 6-8, 8.30-12.30, 1.30-5.30, and in addition to these ten hours, overtime was worked from 6-8 p.m. Among these yarn-winders was a young unmarried woman of thirty-two who claimed that by not working before breakfast (from 6 to 8 a.m.) and by refusing to work overtime (from 6 to 8 p.m.), she turned out more in the remaining eight hours than if she had worked the whole twelve hours. Her claim was put to the test by comparing her monthly output during eight hours per day with that of three first-class hands working during the first fortnight at twelve hours per day and during the second fortnight at ten hours per day. Despite the fact that the short-timer stayed away the whole of one working day and three half-days during the month, her output of 52,429 bobbins easily beat the average output of her three competitors' 48,529 bobbins. In 32 per cent. less hours of work she produced 8 per cent. more work. Further, the output of the three competitors was greater by more than 5 per cent. during the second (as compared with the first) fortnight, when no overtime was being worked and the length of the working day was thus reduced by 16.6 per cent." (Charles S. Myers, *Present-Day Applications of Psychology*, 1918, pp. 15-16.)

What appears to be true of this particular instance, seems to hold generally, as the following excerpt implies: "We have an even more significant case in Durham, where the hewers have for many years enjoyed a seven-hour day from bank to bank. Nevertheless, the output per underground worker in Durham is fully equal to that of the other districts where more than an extra hour is worked. . . . In the United States the reduction of the hours of labour in coal mining from 10 to 8 presently led, as is officially reported, to a positively larger output for each workman per day than the highest output of the 10 hours. The Industrial Commission of the Supreme Court (*Final Report*, Vol. II, 1902) reports that 'in the industry of coal mining the shorter working day has increased the efficiency of both workmen and the management'. We see no reason why a like increase in the efficiency of both workmen and the management should not be manifested in this country on the now projected reduction of hours from nine to seven per day." (Quoted from the Coal Commission Report, in *Engineering and Industrial Management*, March 27th, 1919, p. 208.)

METHOD OF DETERMINING STANDARD PROCEDURE.—In certain tasks the method of determining standard procedure would be to apply the general methods of simplifying motions, increasing speed, reducing fatigue, etc. In simple tasks of a transient character, and in the daily attempts to economise wherever possible, general principles would form the chief guides. In other tasks, however, where their nature is frequently the result of historic development, and where tools and machinery are involved, it is manifestly impracticable to re-invent the process, without regard to established usage. In such cases the best current practice has to be studied. Taylor suggests the following procedure: "First, Find, say, ten or fifteen different men (preferably in as many separate establish-

ments and different parts of the country) who are especially skilful in doing the particular work to be analysed. *Second.* Study the exact series of elementary operations or motions which each of these men uses in doing the work which is being investigated, as well as the implements each man uses. *Third.* Study with a stopwatch the time required to make each of these elementary movements, and then select the quickest way of doing each element of the work. *Fourth.* Eliminate all false movements, slow movements, and useless movements. *Fifth.* After doing away with all unnecessary movements, collect into one series the quickest and best movements as well as the best implements." (*The Principles of Scientific Management*, 1911, pp. 117-118.) Gilbreth pursues this study by means of highly delicate recording instruments.

TRAINING.—Taylor finely conceives of the training of the worker, which evidently ought to be as thorough as that of the professional man. He says: "It should be remembered that the training of the surgeon has been almost identical in type with the teaching and training which is given to the workman under scientific management. The surgeon, all through his early years, is under the closest supervision of more experienced men who show him in the minutest way how each element of his work is best done. They provide him with the finest implements, each one of which has been the subject of special study and development, and then insist upon his using these implements in the very best way. All of this teaching, however, in no way narrows him. On the contrary, he is quickly given the very best knowledge of his predecessors; and, provided (as he is, right from the start) with standard implements and methods which represent the best knowledge of the world up to date, he is able to use his own originality and ingenuity to make real additions to the world's knowledge, instead of reinventing things which are old. In a similar manner, the workman who is co-operating with his many teachers under the modern scientific management has an opportunity to develop, which is at least as good as, and generally better, than that which he had when the whole problem was 'up to him' and he did his work entirely unaided." (*Ibid.*, pp. 66-67.)

Owing to practical necessities Taylor was engrossed in what one might term re-education. Early training is, however, an imperative need. "Skill is largely a matter of training," say F. B. and L. M. Gilbreth, "and the greatest skill can be acquired in the shortest amount of time when right habits are acquired as the direct result of right methods having been taught from the start." (*Measurement of the Human Factor in Industry*, 1917, p. 4.) The problem of a scientifically standardised form of training apprentices is yet waiting solution.

CONCLUSION 11.

Need of Systematically Framing Hypotheses.

§ 90. A fact may be defined as an assumption in closest accord with sifted knowledge, and a theory as a proposition about the complete correctness of which full assurance is lacking. Wherever in a scientific enquiry, therefore, we take into consideration what is not strictly before us in space and time, or, what amounts to the same thing, wherever we utilise the memory, we indulge in framing hypotheses. These may be infinitely near the truth or infinitely removed from it, but hypotheses they remain. The office of a scientific methodology is to ensure that they shall be framed when required by the circumstances, that they shall not be framed when not required by the circumstances, that they shall be discarded or modified when found

inapplicable, that they shall be verified when formed, and that they shall be, as far as possible, extremely close to the truth.¹

Since all the Conclusions represent to a certain degree attempts to satisfy the standard formulated in the foregoing sentence, and whereas the problem is incidentally treated in some detail in many of the Conclusions, besides having a special Section allotted to it in Part II, it does not appear necessary to enter into particulars in this place, but just to state the need of habitually and methodically framing hypotheses.

Recapitulating the subject, we may say that the investigator should systematically devise the most extensive hypotheses consistent with the stage of an enquiry, whether it be in the matter of observation, generalisation, deduction, definition, etc.; that he should systematically verify, improve, and extend his hypotheses; and that he should be aware that where a modicum is known, the hypotheses formulated are almost certain to be substantially erroneous and that the time spent on verifying them is likely to prove worse than wasted. Only this need be added that the common practice of accumulating conjectures regardless of adequate preliminary observation and subsequent adequate verification is a token of the absence, rather than of the presence, of scientific proficiency.

Conclusions dealing somewhat circumstantially with the matter of this Conclusion are 5, 6, 25, 28, and 29, and most especially 25*d*.

CONCLUSION 12.

Need of Co-operation in Scientific Work.

§ 91. Science knows no barriers of nationality, and contributions receive fair consideration whether they emanate from London or Paris, Tokio or Teheran. A moment's reflection will convince any one that but for this frank national and international co-operation, science would be yet embryonic in form, and its text-books be mostly filled with hearsay. Indeed, but for the fact of civilisation, with its open door, replacing barbarism, with its closed gates, there would be practically no intercommunication between peoples, and without this it is difficult to conceive the existence of many sciences, inasmuch as these are almost invariably dependent on data culled from every region of the globe.

However, unpremeditated co-operation between peoples is traceable down to the remotest antiquity. An illustration of

¹ "Hypotheses have often an eminent use: and a facility in framing them, if attended with an equal facility in laying them aside when they have served their turn, is one of the most valuable qualities a philosopher can possess; while, on the other hand, a bigoted adherence to them, or indeed to peculiar views of any kind, in opposition to the tenor of facts as they arise, is the bane of all philosophy." (Herschel, *Discourse*, [217].)

this may be found in how Aristotle came to be pre-eminent among the scholastics. Byzantine scholars acclimatised him in their land and also popularised him in Egypt. When in the seventh century the bellicose Arabs invaded the latter country, they became disciples of Aristotle, and carried his fame to wherever their conquests extended. Thus he came to be studied in Spain, of which the Arabs had become the masters. And thence the works were gradually introduced to the rest of Europe.

Collaboration, which Bacon so strongly recommended, is becoming more and more prevalent. Dictionaries, encyclopedias, and text-books are now frequently compiled by companies of scholars; the heavens are at present being mapped out by about a score of observatories concertedly; an International Committee deals with the work done in relation to the exact determination of atomic weights, whilst an International Commission of Scientific Aeronautics directs the studies for upper air research; national and international scientific institutions, academies, conferences, and periodicals, facilitate exchange of opinions and co-operation; and men of science, especially physicists and biologists, not rarely keep in intimate contact with others who are pursuing kindred lines of enquiry.¹ Except for this fact of collaboration, scientific advance would be much retarded. The knowledge we possess of radium, the advances which are being recorded in chemistry, and the progress registered in the biological sciences are largely due to men readily

¹ Here is an example: "About the middle of the nineteenth century there came into existence in most countries organisations, either voluntary or State supported, for collecting observations of weather from a number of places and for summarising the observations when collected. At the present time the land surface of the globe is covered by a network of stations at which regular observations of weather are made on a definite plan. Over wide areas, especially in the tropics, the network is of very wide mesh, so that many facts which it would be desirable to record escape notice. The organisation of the work is still imperfect in other respects also, but each year sees a further approach to the meteorologist's ideal of securing regular observations from the whole world, so that he may be able to study the world's weather changes as a whole. Nor is the ocean neglected, for most ocean-going ships keep a regular record of weather observations. Each station or ship forwards its records regularly to the central institution of its country for correlation with those taken elsewhere. In this way a vast amount of material is collected and made available for study or for application to the affairs of every-day life. The central institutions of different countries are kept in contact with one another by periodic conferences of their directors, which conferences elect from their members a committee to deal with current questions." (R. G. K. Lempfert, *op. cit.*, pp. vi-vii.)

The need for co-operation is also appreciated in the efficiency movement. "Wherever possible more than one observer should be set to work, as the statistics will be much more valuable if personal idiosyncrasies can be eliminated by comparison and repetition." (M. and A. D. McKillop, *op. cit.*, p. 84.) So, too, Mr. and Mrs. Gilbreth urge that methods of efficiency should be discovered by trade associations rather than by individuals or firms, and that skill should be transferred to bodies of workers simultaneously rather than to one individual at a time.

absorbing the conclusions which others have reached. "A Darwin now no sooner propounds original ideas concerning the evolution of living creatures, than those ideas are discussed and illustrated, and applied by naturalists in every part of the world. In former days his discoveries would have been hidden for decades of years in scarce manuscripts, and generations would have passed away before his theory had enjoyed the same amount of criticism and corroboration as it has already received." (Jevons, *Principles of Science*, p. 575.)

With the passage of time wide collaboration will become increasingly recognised as indispensable in all scientific work, and thereto will probably be added Commissions of Experts who will offer advice and final criticism. An incalculable waste obtains in private adventures of a scientific character, and it is only consistent to demand that if *truth be a collective product, it should be arrived at by systematic co-operation*. In the place of the present-day motto "One man, six books", there ought to be the device "Six men, one book", and such volumes, not too bulky ones either, should cover much ground, embracing preferably a substantial part of some subject or science. It ought not to be left to the indiscriminating fates to determine who should initiate or continue a line of investigation, nor should an individual toil for years without impartially examining the labours of others and without soliciting and receiving from many competent quarters the soundest advice, assistance, and criticism.

Right to the end of the eighteenth century, and even beyond, scurvy caused terrible havoc among the seafaring population. Thousands and tens of thousands succumbed to this loathsome scourge. Yet already in 1734 Bachstrom correctly diagnosed its cause:—

"From want of proper attention to the history of the scurvy, its causes have been generally, though wrongfully, supposed to be cold in northern climates, sea-air, the use of salt-meats, etc., whereas this evil is solely owing to a total abstinence from fresh vegetable food and greens; which is alone the true primary cause of the disease. And where persons, either through neglect or necessity, do refrain for a considerable time from eating the fresh fruits of the earth and greens, no age, no climate or soil are exempted from its attack. Other secondary causes may likewise concur, but recent vegetables are found alone effectual to preserve the body from this malady; and most speedily to cure it, even in a few days, when the case is not rendered desperate by the patients' being dropsical or consumptive." (Quoted in *Report on . . . Vitamines*, p. 38.)

For those on the high seas the above advice may have seemed a counsel of perfection. However, the appropriate remedy was also not unknown. "Lind recounts the tragic history of four ships which sailed from England to Bombay in April 1600,

carrying 480 men on board, including merchants and other officials, in order to establish the East India Company. The Commodore upon his own ship had arranged for a regular issue of lemon juice, three tablespoonfuls daily, to all hands, and four months later, when the flotilla reached the Cape, his men were all in good health. On the other three ships, however, the seamen were so severely attacked by scurvy that the passengers had to work as common seamen. In all 105 men died from scurvy during the voyage, and when Bombay was finally reached the entire work of unloading had to be performed by the crew of the Commodore's ship." (*Ibid.*, pp. 57-58.)

Thus a glaring lack of co-operation, of learning by the experience of others, has in this as in so many other cases been highly prejudicial to the welfare and progress of mankind.

In the more highly developed sciences, where it is customary to consult colleagues and to submit from time to time for public criticism provisional results obtained in an enquiry, we are approaching the co-operative ideal, and the future will presumably know little of scientific work not undertaken and executed in collaboration. How this is to be accomplished, we cannot profitably discuss here; but why should there not be instituted international bureaus for each branch of science, each bureau publishing in an international or in an internationalised language a periodical, a standard primer, and elementary and advanced text-books to be used internationally; and why should there not be formed, besides intermediate bureaus embracing a complete science and groups of sciences (physics, biology, etc.), a central bureau of science connecting these and issuing a magazine and standard primers of science akin to Huxley's *Introductory* and Paul Bert's *First Year of Scientific Knowledge*, and one or more advanced manuals?

At the same time the conditions of co-operation must be respected. For those, for example, who concern themselves with the cultural sciences, to co-operate—as Prof. Small in his inspiring *The Meaning of Social Science* proposes—in ascertaining the dynamic factors involved in a particular historical event, would be, in our judgment, futile in most cases at present, because feebly developed sciences applied in conjunction to one complex problem would only augment the prevalent confusion. However, as the stores of reliable knowledge grow through the ages, such co-operation not only becomes practicable, but is practised on an imposing scale. We have to no small extent already reached this stage.

Co-operation in research work, incredible as it may seem to many, is becoming a reality in industry and commerce. Owing chiefly to governmental initiative and assistance, Research Associations are being formed by the leading industries in England. Added to this, researches of all-national importance are conducted by special governmental committees; and there is the brightest prospect of English effort being linked with the efforts of other nations in the same direction. The condition for a

general and continuous advance in the solution of industrial and commercial problems is thus given. Besides, it is a growing practice for establishments to call in the "scientific manager" or "efficiency engineer" for the purpose of reconstructing them on a scientific basis. We may hence confidently look forward to the establishment of a science of efficiency,¹ produced and applied co-operatively. The era of secrecy, incompetence, and isolation in business matters is happily passing.

As profound is the change which is proceeding in a cognate direction. Collective bargaining was long resisted by employers (and in some quarters is still resisted). However, not only is the principle now generally conceded that workmen may belong to a trade union and that they may be represented by the officials of their unions, but the representatives of the employers' and employees' unions meet and amicably arrive at collective agreements. In the workshop, too, the worker is ceasing to be arrogantly or philanthropically treated, and workshop and employment conditions are coming to be decided by joint committees of employers' and workers' representatives. Already, also, representation of the workers on boards of management is being introduced, and to a share in the general management a share in the profits is coming to be added. Legislation is being similarly affected. Only a few years ago, the government of the country, save for the voting at elections, was entirely out of the hands of the people. A far-reaching democratic principle is at present making headway, and men will soon be wondering how undemocratic the past was. In advanced democratic countries, for instance, industrial legislation is now prepared by Governments in close co-operation with employers' and workers' representatives, and the same principle is tending to be applied in the preparation of all forms of legislation. It is one of the happiest auguries of the coming co-operative world State that the diverse Peace Treaties concluded between the late belligerents contain a provision for the holding annually of International Labour Conferences. These have for their object the framing of international draft conventions on labour matters, and are attended by a fixed number of representatives of Governments, employers, and workers—2 Government, 1 employers', and 1 workers' representative for each country. In other words, the day does not appear to be distant, when Governments, firms, and other bodies, and individuals, too, will tread the ethically and methodologically more excellent way of co-operation.

In the centuries to come there will be an end to producing many or ponderous books, whilst unreliable accounts and inadequate theories will reach the vanishing point. Relatively few comprehensive and fascinating pamphlets and lectures, in addition to reports, text-books, and encyclopedias, will enlighten humanity, and it will be acknowledged both that science should rule man's daily life and thought and that such science must be the effect of collaboration.²

¹ A work on the subject, heralding the dawn, is *Fundamental Sources of Efficiency*, 1914, by F. Durell.

² "In 1907, 1042 authors presented to the world 2131 papers on meteorology, 229 on atmospheric electricity, and 180 on terrestrial magnetism." (*Report of the British Association for the Advancement of Science*, 1908, p. 589.) Manifestly men's ambition should be to spend practically a life-time in elucidating a single large question—as was the case with Gibbon, Adam Smith, Darwin, and others, and to attempt this by consultation and co-operation. The prevailing fashion, even in the highest quarters, of innumerable scholars producing many varied essays is apparently not the best one. On reflection it would be generally admitted that the quality of one's performance is immeasurably raised in value if time is freely bestowed on it, and that, in the absence of systematic provision for every thought being followed up,

CONCLUSION 13.

Need of a Provisional Conception as to the Form which an Enquiry should assume.

§ 92. In the Conclusions which succeed this one, we shall deal with the various stages of an investigation in synthetic order and with the methods applicable to them. In this place, for the sake of providing a synopsis, we offer miniature illustrations of the conception which should dominate the inquirer in respect of his general procedure. Since, however, all that we could state is necessarily contained in far greater fulness in the subsequent portions of the treatise, the present Conclusion must inevitably appear seriously incomplete. Its object may therefore be said to be to indicate by a few unpretentious examples in what spirit an enquiry is to be entered on rather than to determine every one of the methods which need to be employed for the purpose of bringing it to a successful issue.

To level wits, was Bacon's methodological end, and this should be manifestly also the ideal of every methodologist. The test, that is, of a methodology, is the aid it renders the inquirer, and the burden it removes from his shoulders. So far as Bacon's chief example, the one relating to the investigation of heat, is concerned, he supplies four definite rules, and implies that classes of facts should be exhausted, that experiments should be made whenever practicable, that utilitarian ends should be kept in view as well as theoretical ones, and that opinions should be loosely held until established by irrefragable proofs. Granted that these helps are invaluable, they are yet far removed from according the inquirer all the guidance he requires.

Suppose we go much further. By Conclusion 19, the inquirer is greatly aided in the collection of facts. By Conclusion 20 his path is made comparatively smooth. By Conclusions 17 and 21 he is helped to avoid a number of concealed traps which might seriously vitiate his conclusions. By Conclusions 27 and 28 much that is obscure and complicated would be illuminated and disentangled. His course will be also determined to a crucial extent by Conclusion 3. Conclusion 16 will, naturally, contribute appreciably to his success. In all this, the general course of procedure—clarity in regard to the problem to be examined, observation, generalisation, verification, deduction, application, classification, and interim and final statement—is assumed.

Even so, however, the methodological ideal is not completely satisfied. We ought to postulate, besides, thorough intimacy

there is an appalling waste of energy. For instance, how much more just the present author would have been to his readers and to his theme, if, through exclusive devotion and through enlisting wide co-operation, he could have dealt with the whole of his theme instead of with only a portion thereof, and if he could have avoided many imperfections which no doubt materially reduce the value of this treatise.

with the whole of the methodology and some practice therein, and being well-informed generally and in the particular subject.

The above being conceded, if the problem treated of in the illustration which follows were placed independently before a score of persons, the results arrived at by them, supposing they agreed to become investigators, should be nearly the same. The divergences ought to be trifling, more in the manner than in the matter. Very little should be left to hazard or to agitation of wits.

The illustration should be examined from this standpoint. Much will be perceived to follow directly from methodological premises; but owing to the methodological system having been slowly and laboriously evolved, others than the author should be able to present a better articulated and more patently methodological treatment of the subject proposed. In fact, the criterion of a methodology is not what the methodologist accomplishes or fails to accomplish; but what a well-informed and favourably situated individual can achieve by its means in a particular enquiry.

I.—FIRST AND DETAILED ILLUSTRATION.

*First Stage.—Statement of the Problem.*¹

§ 93. It is asserted that the white race is greatly superior intellectually, morally, and practically, to all other races. I resolve to probe this assertion, and to examine it with a view to detecting whether there exist any material differences between races in respect of the qualities mentioned. Having regard, however, to the nature of the question, I cannot expect to receive a quantitative reply in the rigid sense. I can only ask for proof of "substantial" equality, inequality, or difference: for proof, for example, that all peoples, with the possible exception of a negligible fraction, are virtually or apparently equal in respect of the characters mentioned. Again, in speaking of superiority, I exclude for the sake of simplicity, as implied, all superiority in the possession of humour, of beauty, and even of physique apart from health, and include, as stated, only intellectual, moral, and practical (such as initiative, enterprise, determination, independence, courage, etc.) traits. Some of the details as to the cultural capacity of individuals, can be ascertained with relative ease in our age of education and travel and the publication of reports, whereas the problem of the interdependence of civilisations requires for its solution the consideration of the facts elicited by history and anthropology.

Being clear in our minds in regard to the problem to be investigated, we may proceed.

¹ Conclusions 14-15.

*Second Stage.—Examination of Relevant Data.*¹

§ 94. Having formulated our problem, we examine the relevant facts in order that we may be in a position to generalise. Here we are specially guided by Conclusions 19, 20 and 17, and bear in mind Conclusion 21. Conclusions 3 and 16 are, of course, utilised to the full.

(a) **TERMS.**—What do we roughly mean by “intellectual, moral, and practical superiority”? What do we mean by “race”? What do the terms “white” and “non-white” signify to us? What do we mean by “greatly superior”?

(b) **EXISTENCE.**—Do races exist at all, or is their existence relatively doubtful or relatively indubitable?

(c) **INDEPENDENCE.**—Is each nominal race wholly or partly unique, or to what degree is it part of something larger, or composed of various or varying races, or enters largely or otherwise into the composition of the human race in general? Or, Are races radically distinct, or, if not, to what degree do they resemble each other?

(d) **INTERRELATION.**—Is each race culturally dependent, and to what degree, on preceding and co-existing races? Does each race constitute the cultural condition, and to what degree, of co-existing and succeeding races? Or what other cultural relation does it bear to preceding, co-existing, and succeeding races?

(e) **EXTREMES.**—What is the result of examining each civilisation from its one or more earliest, to its one or more later, stages? Or, Have white people always been superior? If not, for what period have they been superior, equal, or inferior to non-whites? Which white and non-white peoples, and where and when, were the first to be more or less highly civilised? And how far have the earliest to latest white civilisations been independent, of or dependent on non-white civilisations, and *vice versa*?

(f) **DEGREE.**—Do differences of degree relating to superiority, race, or whiteness, make any fundamental or what difference to the conceptions underlying these terms, and are the differences connected by a chain of degrees? Or, Are all men of one capacity, one race, and one colour, only differing, owing to circumstances, in unimportant anatomical details, in being lighter and darker, and in quantity of culture assimilated according to opportunities? Or are the differences absolute and due to heredity? In which case, what is the origin of the differences, and how far can they be deliberately produced? Or are the differences relative and traceable to the environment? In which case, what is the origin of the differences, and how far can they be deliberately produced?

¹ See Conclusions 16–24.

(g) EXPERIMENT.—By gradually and proportionately withdrawing from, and also bestowing on, individuals or groups of different races, educational, economic, social, and other advantages or disadvantages, do we find, as a consequence, that the races do or do not differ substantially or appreciably in intelligence, morals, or practical capacity? Or, What is the effect of an excellent upbringing and schooling on members of a race supposedly very backward and of corresponding neglect on members of a race supposedly very advanced, or of the same good or bad nurture on the several races?

(h) MODALITY.—What is the precise distribution and position in space and time of each race and civilisation? What are the numbers and the divisions of each race and the intensity of influence of every part of each civilisation on the others? What of the precise pure, average, casual, momentary, time-produced, environment-produced, transitional, exceptional, abnormal, perfect, and imperfect states of each race and civilisation? What do we learn by examining the evolution, origin, history, development, influence, and transformation or dissolution of each alleged race and its civilisation? What of the precise degree of more or less permanent idiosyncrasy, abnormality, mental confusion, ignorance, error, prejudice, and deception of the inquirer and of those who have previously ventured on statements concerning the subject?

(i) DIALECTICS.—What is revealed to us by searching for facts possibly contradictory, contrary, opposite, etc., to those alleged to exist in or between races or divisions of races in respect of moral, intellectual, and practical superiority?

(j) COMPARISON.—What appears to be the degree of the resemblance or difference of the compared races and their component parts, if we observe them under profusely varied conditions of space and time including conditions most similar and dissimilar? Or, Are there any or many white peoples or individuals on the same plane as, or on a lower or higher plane than, non-white peoples or individuals? (Note, so far as features are concerned, preponderating resemblance of Australian, Ainu, Dravidian, and Veddas, to Caucasians.) Are there any or many non-white peoples or individuals on the same plane as, or on a lower or higher plane than, white peoples or individuals?

Finally, following the first table of the Primary Categories, we ask: What are the material aspects—the precise Elementals, Constituents, Form, Dependence, Action, Cause, Resemblances, Classification, Position, Differentiæ, Details, etc., suggested by a circumspect preliminary investigation embracing the process of observation?

*Third and Fourth Stage.—Generalisation and Interim Statement.*¹

§ 95. After prolonged sifting of the chaff from the wheat, and after applying the necessary generalising and verifying methods indicated in Conclusions 25 to 29, we clarify our thought by formulating, for instance, the interim statement that *man is the sole specio-psychic being*, or, less tersely, that *man is the sentient being which, for satisfying its needs, primarily depends on species-developed and environmentally preserved culture*; or, more exhaustively, that *what differentiates man most truly is that the necessary means for adequately gratifying his needs are, in a growingly satisfactory form, provided—not, as in animals, by instinct, by individual intelligence, by learning a few things from neighbouring members of the same species, by incidental traditions, by group co-operation, or by a combination of several or of all of the just enumerated means, but—by the steadily increasing collection of material and other inventions and discoveries made and developed through the ages by his species as a whole and transmitted traditionally or environmentally from generation to generation.* In more formal terms: Man most nearly resembles the mammals belonging to the order Primates, and is specially distinguished from (a) the other Primates, by his completely erect posture and higher development of extremities and brain, and from (b) all animals, including the Primates, by his mode of life being a cumulative and environmentally preserved species-product, that is, by his depending, instead of on almost entirely inherited means and methods for satisfying his desires, on in substance species-discovered, invented, adapted, and improved means and methods environmentally preserved.

These definitions satisfy the important canon (§ 110) which requires that a whole subject should be summed up in one brief statement wherever possible; but, to be of no uncertain value, the main implications of the definition should be stated for the purpose of placing ourselves in a position to test the correctness and the importance of the definition. With a crisp definition and a compressed deductive statement before them, author and reader obtain a bird's-eye view which naught else could replace, and which should be, therefore, only omitted when extraordinary circumstances render the attempt inadvisable or prohibitive.

*Fifth Stage.—Theoretical Deductions.*²

§ 96. The interim statement reached at the fourth stage implies: (a) Since every species of animal known (other than man) is for all intents hereditarily determined, and in no degree

¹ See Conclusions 25–30.

² See Conclusion 31.

can be species-determined, in its conduct, the mental outfit of any member of any known animal species must be necessarily almost infinitely poorer than that of the average human being who, by nature just superior intellectually to his immediate animal precursors, has assimilated the substance of the material and other inventions and discoveries of his species past and present. (b) Since the individual is a specio-psychic being, it follows in the first place that his connection with the rest of his species in space and time cannot manifestly be through biological heredity, and must therefore necessarily be through post-natal communication; that such communication must express the thoughts of others, and that these thoughts can be only transmitted through some external medium and represent material and other inventions and discoveries embodied in material and mental tools and tool-made products; that each of the hundreds of millions of individuals, allowing for favourable and other circumstances, pours his modest contribution into the common reservoir of thoughts, as a consequence of which there ensues historically a colossal growth and improvement of material and other tool and tool-made products until the first cultural attempts of men are almost infinitely transcended in scope and effectiveness; that circumstances being of such crucial importance, and the single individual having such indifferent power of advancing beyond what has been accomplished, the extremes of culture and non-culture, errors innumerable, and serious cultural leakages, will be found in the species until a very high state of cultural, and consequent closely co-operative, development is reached; that, generally stated, *human life is potentially to-day of necessity almost infinitely richer, more varied, more progressive, more interdependent, and more perfect in regard to peoples and ages than the life of any animal species, and that this difference will be proportionately accentuated with the flight of time*; that since man depends on culture, since culture is constituted of material and mental tool-made tools and their products, and since all men can benefit by this culture and augment it, it seems irresistibly to follow that the individual will, historically and broadly speaking, gradually come to be culturally connected with the species as a whole, *i.e.*, the individual, on the side of his mentality, irresistibly develops into a species-reflecting being, from which conclusion, again, all the preceding and succeeding characteristics follow. (c) Since the civilised state is an environmental datum, a human being, if left to himself, or left with others who are completely uncultured, would not be appreciably more cultured than are any of the other highly intelligent animals (*vide [a]*). (d) Man, because he is a specio-psychic being, is, in propitious circumstances, capable of assimilating virtually the substance of any civilisation however advanced (making hypothetical allowance for a few insignificant tribes). (e) Since man's self-culturability

is virtually zero (vide [c]), and his capacity for being cultured is virtually infinite (vide [d]), there is virtually an infinite distance between the minimally and the maximally cultured man, and consequently any differences between any two individuals in respect of being cultured (Zulu in his Kraal, University Professor in his Chair), are traceable first and foremost to the circumstances in which they are placed, which is equivalent to stating that human beings are, by birth and because they are mentally species-dependent beings, almost infinitely more like than unlike each other morally, intellectually, and practically. (f) It follows from (e) that the stock of humanity's moral and other acquisitions, divided by the number of human beings who have lived, positing the actual physical and cultural conditions, virtually yields the latent capacity of the individual to contribute to the stock of human acquisitions, and that, conversely, the quantity of effort put forth by one individual, under the above conditions, multiplied by the number of human beings who have lived, virtually yields the stage of culture reached. (g) Since culture, as species-developed, is necessarily a product of many minds and many ages (vide [f]), it is of vital importance for each generation to preserve, adapt, improve, and increase the stock of humanity's material and other inventions and discoveries, which process, seeing the weakness and the fallibility of the unaided human individual (vide [c]), must be, in advancing stages, normally performed, so far as non-material objects are concerned, by means of collective and separate customs and institutions—economic, educational, moral, religious, legal, political, scientific, literary, artistic, etc. (h) Since man is adapted for the specio-psychically determined state, he lives exclusively and necessarily in that state and is unfit for any other, which does not however preclude that in certain departments of life man does live almost wholly still on the animal stage—that is, without the help of pan-species culture (vide [l]). (i) Being primarily adapted for the specio-psychically determined state, man is only truly himself when he is truly cultured, and is the more himself the more he is cultured, being ideally himself when he is ideally cultured. (j) Being only truly himself when he is truly cultured (vide [i]), he naturally tends, if not discouraged, to improve the state of culture which surrounds him, and cannot rest till the stage of culture becomes in every respect ideal. (k) Since man ultimately aims at an ideal state of civilisation (vide [j]), and since civilisation ignores territorial limits, he ultimately aims at an ideally organised universal civilisation and universal fellowship. (l) Since man is by nature culturable, but not cultured, he does not, apart from science, know that he is culturable, nor that he should not depend on unenlightened instinct or passing reflections; he therefore frequently entertains erroneous notions pertaining to his essential nature, thinking that he is acting as a cultured

being when he is not, that he exercises control over himself when he is really controlled by his impulses, that he is satisfying his true nature when he is not, and that he can rely on his native capacity for guidance when this does not lift him above the animal stage. (*m*) Innate appetites, instincts, feelings, etc., are not distinctively human qualities, and are therefore excluded from our conception of man so far as cultured, and, since man is indefinitely culturable (*vide* [*d*]), it follows that the enormous pressure of species-produced culture, when concentrated, is capable of overcoming any resistance that might conceivably be offered by man's sub-human nature. And, (*n*) the further humanising and socialising of man's nature, consequent primarily on the growth of culture, with, later, the aid of artificial biological selection, will lead to the educational process meeting eventually with progressively fewer obstacles and becoming therefore progressively less arduous.

To summarise. Our interim statement involves that, since culture is a progressive pan-human product, humanity is capable of achieving in the course of the ages virtually everything, the individual as such virtually nothing; and, accordingly, our theoretical aim is satisfied when we learn that all moral, intellectual, and practical distinctions between peoples or persons are, for all intents, due to specio-cultural, and not to inborn, causes.

Sixth Stage.—Practical Deductions.¹

§ 97. Our task is not complete, our truth is only a partial one, until we have formulated the practical deductions suggested by the interim statement. Some of these we shall now proceed to enumerate.

1. *Society*.—The growth of species-determined culture presupposes incessant contact and collaboration between individuals, and this involves increasingly co-operating and organised societies, the process tending towards a universal civilisation and a universal organised fellowship. The cardinal importance of Societies is therefore self-evident, and anarchist and extreme individualist theories are thereby disproved.

2. *Equality*.—The men and women in a community are, by definition, capable of assimilating, in favourable circumstances, the substance of any civilisation known to us. They should all therefore have the opportunity of living a life commensurate with their capacity of enjoyment and work. Consequently—

(*a*) All social, political, and other discriminations based on family, on sex, on class, on caste, on nationality, or on race, disregarding as they do the fact that man is first and foremost a cultural being, should be abolished;

¹ See Conclusion 32.

(b) All individuals, being for all purposes equally dependent on pan-human culture, should command identical opportunities of developing, labouring, and living;

(c) The needs of specio-cultural beings being intrinsically similar, one general standard of living should obtain, consequently one standard for reward of services;

(d) One unchanging moral standard should be applied to all individuals and groups of individuals—equal kindness, courtesy, consideration, respect, etc., though this does not preclude paying most, but not exclusive, attention to the nearest duties (*our* home, vocation, country), and being guided by the actual requirements of others;

(e) The sexes being equally dependent on pan-human culture, self-respect demands that marriage should be monogamic and that both partners shall share authority equally; and

(f) Social advance should depend on the well-directed and well-organised individual efforts of the many rather than on the activities of a capriciously selected or favoured few—that is, the spirit of democracy should dominate all human inter-relations.

3. *Education*.—Culture being the measure of man, we should provide for its assimilation by each and all, and hence it follows that thorough home and school education for all—moral, intellectual, hygienic, æsthetic, and vocational—is indispensable, and that it is a primary social necessity to perfect the educational ends and the methods of educating teachers and children.

4. *Science*.—Since abundance of sifted knowledge, combined with deliberate collective thought, are man's distinguishing weapon, and since all wholly or partially instinctive or individual methods of dealing with general problems are pre-human because not pan-human, science should be man's guiding genius in all departments of life and thought.

(a) This involves that the desire for attaining strength, health, happiness, and the satisfaction of appetites and impulses, should be determined by ideas enlightened by science—ideas which would urge the implanting of the love of the good, the true, the hygienic, and the beautiful, as well as the development of a joyous temperament, and would, it is probable, rule out as superfluous luxury, intoxicants, narcotics, gambling, playing for stakes or otherwise than rarely, substantial dependence of happiness on amusements, and would certainly condemn as brutish unchastity in the unmarried and infidelity in marriage.

(b) It equally involves, on the social side, that all war, rewards and punishments, unfriendly words and deeds, uncritical assignment of motives, anger, scolding, ridicule, indulgence, coaxing, bribery, and argumentation are unwise and ineffective when applied to personal, social, national, international, inter-racial, and other human relations, and should be replaced by methods resulting from scientific study, which counsel the ex-

clusive application of rules of conduct of the type mentioned in paragraph 10 below.

Other deductions are:—

(c) home education, like school education, should have its roots in science;

(d) the relationship between the two partners in marriage should, besides love, manifest mutual understanding, respect, forbearance, assistance, and companionship, and be illumined by science;

(e) vocations should be grounded in science and should be scientifically acquired and pursued, and the love of good workmanship and of incessant improvement should displace thoughtlessness and the love of routine;

(f) the public services—which are visibly growing in importance year by year—should be re-organised, root and branch, on a scientific and, inferentially, democratic basis;

(g) speculative thought should be discouraged, except where it ensues on carefully ascertained facts;

(h) the best thought being a product of the slow growth of culture, the utmost should be attempted to discover and inculcate the soundest rules for the conduct of the human understanding; and

(i) whilst it is true that without appetites, impulses, and organs, action is impossible, it is knowledge alone which creates man's superiority, even in respect of generating breadth and depth of feeling, and a puissant and unshakeable will.

5. *Co-operation*.—If science is indispensable in every department of life, co-operation is no less necessary, for since culture is a species-product, this implies that there can be no science without the widest co-operation, and that all that humanity has achieved has been through co-operation. Consequently, co-operation is a requisite in every department of thought and action, in the humblest as in the highest spheres, in vocational, social, national, and international affairs, in the inner life of the individual, and between generation and generation. Hence:—

(a) Co-operation in science and in the economic life, and thoroughly democratic and democratically organised governments and institutions, are requirements;

b) Modesty, broadmindedness, appreciation of other persons and peoples, and readiness to learn and serve, as well as virility, originality, initiative, enterprise, and the fixed resolve to add a full quota to the achievements of others, should stamp all individuals and groups of individuals;

(c) Since social conditions, according to this trend, represent the most potent incentives and impediments to the growth of culture in any community, they demand the closest collective attention—more especially they require sanitation and education, the humanisation of the law, democratic rule, friendship among

nations and races, and liberal insurance against illness, incapacity, invalidity, unemployment, old age, and inadequate incomes; and

(d) International co-operation is destined to play a notable part in the future. This may express itself mainly in the adoption of a universal form of speech, writing, and printed characters, to promote and symbolise the unity of the race; in the acceptance of universal measures, coins, post, telegraph, scientific and economic terminologies and units, and rule of conduct; in building roads, railways, canals, air-stations, etc., to connect conveniently every part of the world; in encouraging international free-trade, institutions, organisations, and bureaux; and in establishing an International Legislature, Judiciary, and Administration to decide on justice, and to promote common action, between the nations of the world.

(e) The most intimate form of co-operation should be offered by the home, and should be exemplified therein. Here are two individuals, almost infinitely alike and yet infinitely different, who may strengthen themselves to an incalculable degree by becoming one for life. Furthermore, they may devote themselves in common to the incomparable task of rearing worthy, healthy, and happy offspring—a task which only loving and constant attention on the part of those most nearly concerned can competently perform.

6. *Institutions*.—If science and co-operation are essentials, the necessity of storing in some manner the accumulations of the past becomes evident. Hence institutions and their equivalents are of inestimable value, among the most important of which should be counted the institutions of Government, Law, Marriage, Religion, Arms (in earlier stages), Seats of Learning and Schools, Trades and Professions, Organisations for reform and for industrial, charitable, recreative, medical, intellectual, and other purposes, Libraries, Museums and Galleries, Sciences, Arts and Crafts, Classics, Text-books, etc. Indeed, institutions, or more or less fixed collective aids, are to social advance what the family is to the perpetuation of the species, and the social reformer should have therefore his energies directed first and foremost to the improvement of institutions.

7. *Conservation and Conservatism*.—Since any one generation can add but little to the accumulated treasures of the past, it behoves us, almost above all things, to conserve the substance of what has been transmitted to us by our ancestors, and not to accede lightly to the suggestion of changing the present order or wastefully exhausting the treasures of the earth or of culture.

8. *Progress*.—However, since culture no more originates than ceases with the day and since strict adherence to the principle of conservatism would have kept man in the lowest savage state, progress should be perennially aimed at in all depart-

ments of life and thought and in all institutions. The past, present, and future represent the one flowing and growing stream of culture.

9. *Perfection*.—Since man ultimately seeks to do justice to human nature as a whole, his aim is to accelerate the creation of the complete or perfect man, the man in whom—and, by implication, the world in which—is realised the perfect, *i.e.*, the good, the true, the hygienic, and the beautiful combined.

10. *Rules of Conduct and Action*.—Enlightened men and women will necessarily manifest in all relationships of life a profound fellow-feeling and self-reverence, guided by fullest information and circumspect reasoning, accompanied by geniality and tact, and intelligently realised by a strenuous and firm-bent will which is inspired by the desire to serve the good of humanity.

11. *Supreme End and Sense of Oneness*.—Since the individual is only fully himself when fully cultured intellectually, physically, morally, and æsthetically, his supreme end is to become highly cultured, and, by implication, to promote the cause of culture until the all-comprehensive ideal of goodness, truth, radiant health, and beauty, is attained; and since, moreover, culture is in its essence an expression of the whole of humanity past and present, his inmost thought and being, when truly himself, feels itself one with humanity and identifies itself necessarily and passionately with the life and good of mankind.

12. *Fundamentals*.—All life, of whatever kind, seeks to maintain, adapt, and expand itself, besides tending to develop to higher forms. Accordingly, the prime object and test of culture is harmoniously to maintain, perpetuate, adapt, expand, and develop the life of humanity as a whole. It is true that the fundamental needs of the higher animals are to be found in man, but in man the manner of their satisfaction is determined primarily by historically developed species-culture instead of primarily by inherited predispositions and organs.

*Seventh Stage.—Classification of Data.*¹

§ 98. *Note*.—The peoples and individuals of to-day differ conspicuously in the stage of cultural development which they exhibit; but this diversity must be accidental, since, as recent educational experience and recent history show, this stage is indefinitely raised and lowered by cultural circumstances. It should be also noted in connection with the subjoined analysis that whilst progress grows through the ages, it is not by any means unintermittent or uniform in space.

1.—*Family* (from quasi-animal families without fixed abode, through polygamy, polyandry, and other phases), to fully organised monogamic family with home for centre (relations between children, parents, and other kindred; courtship; finding means of subsistence for family, etc.).

¹ See Conclusion 33.

With the family should be correlated its environment, consisting of

(a) Human Neighbours (from individual to clan, tribe, and to all peoples, including travel, residence, and study abroad), Acquaintances and Friends, also Voluntary Associations for local and specialist purposes to International and Inter-Specialist Organisations;

(b) Animal Neighbours (wild animals—useful, useless, and dangerous to man, domesticated animals, and animals as pets, friends, and fellow-beings);

(c) Plant Neighbours (wild plants—useful, useless, and dangerous to man and to agriculture, frugiculture, horticulture, and arboriculture);

(d) Inanimate Neighbours (soil, air, water, sky, etc., to natural and transformed materials and forces utilised by man).

The product of family life, the child and adolescent, must receive some kind of education, for men's abilities are derived first and foremost from learning, that is, from education and from tradition¹; hence:—

2. *Education* of children; acquisition of vocation; later, historically, schools to universities, and life-long study and research.

With the family should be connected the

3. *Community*.—More or less loosely organised families in small hordes: later, clan; later still, growing and co-operating territorial groups of mostly unrelated families, until Continent State and World State are reached.

And with the community should be correlated:—

4. *Governments* (through occasional Chieftain to Imperial Dynasty and to democratically elected President, and from Headman to Nobility and to a pure educated Democracy), displacing customs more and more (legislative, legal, administrative, productive, protective, and aggressive features of Government), to Parliament of Nations, International Court of Justice, International State Services, and Universal Official Bureaus of Labour, Communications, Motive Power, Science, Art, etc.

The attitude towards others in the community should be well defined; hence:—

5. *Customs* (manner of living; then also manners; and, at first, customs as general method of preserving past acquisitions); from manners based on customs, finally, through intermediate stages, to

(a) Love of humanity as the supreme standard of conduct

¹ Professor F. H. Giddings thus sums up the various classes of traditions: "The primary traditions are: the economic, or the tradition of utilisation; the juridical, or the tradition of toleration; and the political, or the tradition of alliance, homage, and obedience. . . . The secondary traditions are: the animistic or personal, the æsthetic, and the religious. . . . The tertiary traditions are: the theological, the metaphysical, and the scientific." (*The Principles of Sociology*, 1896, p. 141.)

for all, and feeling of oneness with humanity and then with all living things and the Universe; and

(b) The whole of the life of humanity organised by science, with the assistance of art, pursuant to the dictates of morality and to the needs of man's complex nature generally.

Man's universal tool—language—was the condition to all extensive collaboration and advance. Hence:—

6. *Language* (growth from numberless tongues at first barely surpassing animal cries, to, finally, one universal form of simplified and scientised language—speech, writing, and printing).

Life means unintermittent metabolism of energy. Therefore labour—chiefly the expenditure of energy in order to maintain energy—is inevitable for man, as for all living creatures. Hence:—

7. *Labour* (General, *e.g.*, hunting; Special, *e.g.*, making of tools or shelters, to minute specialisation in processes, functions, and localities, relating eventually and mainly to food and health, garments, buildings and furniture, materials, lingual and material modes of intercommunication, supply of raw material energies, and machinery, and government, law, and education).

(a) Living on own work; robbing, enslaving, oppressing, exploiting, or employing others; co-operating more and more, to occasional and organised inter-individual, civic, national, and international co-operation;

(b) Property, as mainly Land, Buildings, and Furniture, and Raw and Manufactured Products; and Grades of Producers and Middlemen (gradually developing from chaotic private property and private enterprise to property and enterprise in the service of the organised common good);

(c) Collective Migrations (to follow game, escape enemies, find fresh pasture land, settle in conquered territories, improve status, etc.); later, Individual and, perhaps, Collective Emigration;

(d) Means of Communication (commencing with beaten tracks and human carriers, and developing into roads, canals, navigated rivers and seas, tunnels and bridges, landcraft, watercraft, and aircraft, postal and telegraphic communication, the press, reports, and books, etc.);

(e) Internal Industries and Commerce (or division of labour within clan or tribe, etc.) to world-wide Industries and Commerce, involving

(f) Means of Exchange (developing from barter to coins, bank-notes, cheques, credit, etc.);

(g) Rude Products to (1) Products all instinct with beauty, concluding in every vocation being enthused with the spirit of art; and to (2) Products of the highest quality, serving only the good, the true, the hygienic, and the beautiful.

There should be some relaxation from toil. Hence:—

8. *Leisure*—Daily, weekly, annual, and other periods of rest. Children's play; later, adults' games and festivities; songs and stories; dance and music; poetry, theatre, history, and literature

generally; travel and leisure pursuits or hobbies; and delight in intimate converse with one's fellows and with nature, issuing in—

9. *Art* generally, and the eventual penetration and beautifying of all spheres of life by the love and the realisation of the beautiful.

In life's turmoil, body and mind are apt to lose their equipoise. Hence:—

10. *Medicine and Hygiene* (sanitation, diet, recreation, birth, illness, burial), leading to the triumphs of surgery and sanitation, of preventive medicine of the body and of the mind, and of hygiene, and finally to hygienic living, and a race sturdy in mind and body.

The attitude towards the master problems of life and towards the Universe should be also defined. Hence:—

11. *Religion*—later, with priests, temples, and religious houses and organisations (philosophy of life and existence, nature, fabled under- and over-world, death and all great occasions of life, holy days, and supposed mysterious influences), developing from almost pure superstition to almost a pure humanism grounded on a scientifically based philosophy of life, and leading also to—

12. *Philosophising*, or speculative thought, because of lack and confusion of data; thence to gradual evolution of—

13. *Science*, theoretical and applied, specialised and cosmic, and growingly reasoned love of goodness, nature, art, health, strenuousness, and joy.

A classification such as the above subserves various ends:—

(a) It aids in focusing a complicated issue having innumerable minor aspects;

(b) It presents a conspectus of the main facts;

(c) It demonstrates the truth of progress;

(d) It shows this progress commencing almost at a zero point; developing slowly through the ages to a remarkably high degree; and promising to evolve further, along old and new lines;

(e) It implies that culture is the outcome of pan-species thought, and that the individual contributes only an infinitesimal proportion of the total culture;

(f) Moreover, the process of the education of children, of adults, and of peoples, involves that culture is post-natally acquired.

(g), (h), etc., etc.

*Eighth Stage.—Final Statement.*¹

§ 99. Lest the enquiry should degenerate into a confusion of detail, we strive to embody the total results in a single formula, theoretical and practical. This formula may be con-

¹ See Conclusion 34.

ceived as follows: *Man is the sentient being which primarily depends on species-developed and environmentally preserved culture for satisfying its needs; and since this is his leading differentia, he must aim at making universally prevalent the highest degree of the good, the true, the hygienic, and the beautiful, at treating all men as culturally equal by nature and capable of the highest and best, and at transforming the whole of mankind into an organic unity.*¹

*Ninth Stage.—Report.*²

§ 100. As pointed out in Conclusion 2, the object of the investigation can only be said to be properly attained when it is duly, clearly, and attractively reported on. For this reason, careful attention should be paid to the report, and this we assume to be accomplished in accordance with the suggestions submitted in Conclusion 35.

Having completed our enquiry, which was undertaken with the object of ascertaining the comparative intellectual, moral, and practical capacities of white and non-white races, we conclude that the cultural differences in races, nations, classes, families, individuals, and sexes, are to be traced first and foremost to cultural causes, and that life should be organised on this assumption.

II.—SECOND ILLUSTRATION.³

§ 101. Consider a second example. We feel that our knowledge concerning our sensations is incomplete, and we desire accordingly to inquire into the matter. Thinking the subject over from the most comprehensive point of view after having conducted a full and ample preliminary investigation, we advance the provisional and most convenient and obvious hypothesis methodologically that fundamentally there exists but one class of sensation. By casting our net so wide, we are prepared for every contingency, though it generally appears, as we proceed in an investigation, that our provisional hypothesis needs to be radically modified. Every class of statement established has, of course, its independent value, and we consult naturally authoritative scientific works on the theme of our enquiry.

We commence with a somewhat exhaustive examination and record of the normal features of each surmised class of sensations (following more especially Conclusions 19, 20, and 3, and § 45), and are helped to augment the list by noting whether

¹ See Conclusion 34 for fuller statement concerning the distinctive nature of man.

² See Conclusion 35.

³ In this and the following illustrations, the course of investigation is only roughly sketched. In practice the form proposed in the preceding Illustration might be perhaps universally applied.

the features of one sense are not also features of one or more of the other senses.

We inquire what features the various classes of sensations possess in common, and what is the degree of the resemblance.

We strive to discover new classes of sensations.

We endeavour, following Conclusion 17, to divide each of the classes of sensations into a number of classes of sensations, and we also seek to show that several or all the reputed classes of sensations fall under one head.

We examine into the elementary facts of any and every class of sensations (ignoring, for the moment, memory, etc.), and determine, following Conclusions 20 and 19, that (a) there is present a stimulus of a particular degree and character persisting for an appreciable period of time; that (b) the mind is not wholly preoccupied, and is therefore affected and consequently reacts; that (c) the mind must react continuously for a perceptible space of time; that (d) the memory needs to be enlisted for the purpose of classing the sensation or experience; and that (e) this implies an attempt at judging and co-ordinating.

We search for instances where several sensations are sensed simultaneously (as in eating an orange: temperature, touch, smell, taste, sound, effort, and pain), beginning with two sensations and gradually increasing their number.

We endeavour to examine sensations at their minimum intensity or clearness (as seeing with eyes approximately or wholly closed) with a view to determining any likeness between sensations, and we examine sensations when minimally or marginally attended to.

We examine more or less highly developed and intense sensations, and from maximum to minimum, and *vice versa*.

We examine whether others' sensations are fundamentally identical with ours, and whether youth, age, etc., or diverse races or periods of history, create any difference, and, if so, the degree of the difference.

We examine, following Conclusion 20, first the least obscure sensations, such as sight and sound.

We examine into human activities which are apparently or relatively unaccompanied by sensations, including automatic and reflex actions, and impulses, and minimal sensations when the attention bestowed on them is imperceptible.

We examine, later, into the nature of pleasure-pain, of the appetites, of internal sensations generally, of the emotions, and whatever other experiences of this character are distinguishable.

We examine, later still, into the nature of the memory.

We examine, last, into the processes of systematic feeling, thinking, willing, etc.

We then complete our enquiry as in illustration I.¹

¹ Mill assumes throughout his *Logic* that the various senses or classes of sensations are ultimate in character and irreducible. Accordingly, he claims

III.—THIRD ILLUSTRATION.

§ 102. In the process of inhaling laughing gas, I accidentally injure my knee, and observe that the injury is not accompanied by pain, as would be normally the case. Assuring myself by varied experiments that laughing gas produces this anæsthetic effect, I conclude provisionally that all bodily pain may be thus overcome, and that laughing gas, or some perhaps even more effective gas, or other substance, should be administered in all dental and surgical operations and wherever there is pain difficult to endure. I proceed then with the investigation on established methodological lines, following strictly Conclusion 3.

I.—Material Aspects.

1. We inquire what appeal nitrous oxide makes to the senses—to sight, touch, effort, pain, hearing, taste, smell, and heat. Also what feelings its presence or inhalation engenders, or what is its effect on the will and the intelligence. Finally, whether it is only indirectly apprehensible.

2. We inquire into the nature of the constituents of the gas.

3. We inquire into its form.

4. We inquire into the precise special facts and factors in the environment on which the gas more or less depends for its existence.

5. We make a study of its precise effects.

6. We trace the cause of its existence and properties.

7. We then consider the relation of laughing gas to other anæsthetics.

8. We ascertain the points wherein it resembles other anæsthetics.

9. We classify the facts pertaining to laughing gas, and then place the gas under a more comprehensive classification.

10. We determine the comparative position of laughing gas among anæsthetics.

11. We inquire into the major and minor differentiae of laughing gas.

12. And we consider the secondary aspects or details.

We take into account then the practical side:—

13. We inquire into the hygienic, economic, moral, æsthetic, scientific, philosophical, and other, value of nitrous oxide.

14. We consider the problems involved in its utilisation, application, and production.

15. And we consider men's subjective attitude towards it—their like or dislike thereof.

that "the ultimate Laws of Nature cannot possibly be less numerous than the distinguishable sensations or other feelings of our nature". (Bk. 3, ch. 14, § 2.) In reasoning thus he begs the question, for the various sensations are most probably complexes, and therefore neither ultimate nor irreducible.

16. Lastly, we prepare a report summarising the enquiry, and, in doing so, respect the principles enunciated on the subject in Conclusion 35.

II.—Modal Aspects.

In seeking to ascertain the Material Aspects, we endeavour to do full justice to what is suggested by the Modal Aspects.

1. Matters relating to time, space, and consciousness require to be determined in detail, according to the table.

2. The degree of static and dynamic facts and factors need to be studied.

3. The pure, average, casual, momentary, time-produced, environment-produced, individual, transitional, exceptional, imperfect, perfect, and abnormal states should be taken into consideration.

4. The changes undergone should not be overlooked.

5. And the personal equation should not escape attention.

III.—Procedure Aspects.

1. We must be clear regarding the problem under investigation.

2. There should be accurate, minute, and, if possible, experimental examination, under the most varied conditions of space, time, and other circumstances, and immediate and scrupulous recording of results.

3. We require alertness, in order not to miss obscure, unobtrusive, and exceptional facts.

4. We shall apply the day-to-day rule and other rules, the simplest practicable case, and what we have learnt as to the testing of divisions.

5. Conclusions 27 and 28, relating to degree determination and dialectical procedure, will be followed.

6. We shall strive after luminous clearness and decided definiteness in thinking.

7. We shall do methodically full justice to the collected rules referring to generalisation, deduction, and application.

8. Lastly, we shall not forget systematic verification, classification, balanced interim and final statements, and a lucid report.

By following the threefold method above suggested, we ensure a comprehensive and thorough investigation of any subject, and this without excessive reliance on fortuitously arisen ideas and without colossal waste of time and energy, as is commonly the case. Familiarity with the contents of the volume would soon render recourse to it almost unnecessary.

IV.—FOURTH ILLUSTRATION.

§ 103. In sundry other series of enquiries a large provisional hypothesis might be also formulated after adequate preliminary examination, although there may be as a rule no hope

of any one person contributing more than a trifle towards its being tested or established. Consider the case of telegraphy. Already Galileo, in 1632, spoke of a method of conversing at long distances by means of the sympathy of magnetic needles. So little, however, was then known about electricity that it is difficult to conceive his propounding any large provisional hypothesis. When, however, many facts had been collected on the subject of electricity, as at the dawn of the nineteenth century, the idea of developing such a hypothesis came within the realm of the practical. Wheatstone might have proposed the hypothesis that a telegraphic system covering the entire globe was feasible, and even have argued that telegraphy should include telephony and the electric transference of designs, both with wires and without, and much else pertaining to heat, light, electricity, magnetism, and chemistry.¹ Such a working hypothesis, if passably correct, would have insured the invention of appropriate instruments with the least possible delay. However, so complicated are the issues involved here that one man cannot contribute much towards clarifying them. In agreement with this we are bound to postulate in almost all the master inventions and discoveries a successive series of workers gradually bringing to relative perfection a particular theory, each man being well informed in the subject and starting where his predecessors left their task. In these circumstances, the discoverer's or inventor's path is largely determined for him, and he need only remember to formulate the largest practicable provisional hypothesis and to explore his theme systematically, as proposed in the First Illustration.

§ 104. If we scrutinise the labours of the most eminent discoverers in biology, chemistry, or physics, we remark in each case *both the wide range of their learning and the magnificent scope of their efforts. Basing themselves on the ripest work of their predecessors, they seek to extend, to re-cast, and further to systematise it, whilst perfecting the traditional methods. They display also a keen interest in the sister sciences*, for these may suggest novel lines of enquiry. The primary method is, therefore, to "follow your leaders", and be as comprehensive, thorough, and bold as they. The Conclusions submitted in this treatise are designed to form a guide to this end. Even so, however, no startling results may be anticipated, no final settling of any capital issue which has not been mainly settled already by other men. (Conclusion 5.) Concerning the *mere detail* in any science or enquiry, *it is doubtful whether much of such detail exists for the trained inquirer*; but granted that colossal

¹ A case of such daring is to be found in Jacques Loeb's works, who suggests that the theory of tropisms, almost certainly applicable to the simplest organisms, may also be applied to the highest organisms including man. Scientific examination will either partly or wholly confirm or confute this theory.

problems may be out of reach, let them be as extensive as practicable and not as restricted as possible. (§ 166.) Detail work is thoroughly consistent with sweeping aims; but *detail work is frequently almost wasted because it is performed in a mechanical way, with the mind relaxed instead of tense.*

Darwin's life-labours pointedly illustrate this:—

"His works are a series of models of the scientific method, because of the rare and happy combination of minute and accurate observation and daring speculation followed by ruthless testing and pruning of his hypotheses. He thought it worth while to notice and penetrate into the meaning of the most insignificant fact, and was capable of sweeping the whole earth for evidence in support of his largest theories. He could take the time to count twenty thousand seeds of *Lythrum salicaria*." (Frank Cramer, *op. cit.*, p. 34.) "There can be no doubt that his great interest in apparently little things, and his efforts to make the most of them, were due to his conviction that important things were hidden behind them, that they were illustrations of general laws." (*Ibid.*, pp. 47-48.) "Perhaps one of the noblest lessons he left to the world is this—which to him amounted to a profound, almost religious, conviction—that every fact in nature, no matter how insignificant, every stripe of colour, every tint of flowers, the length of an orchid's nectary, unusual height in a plant—all the infinite variety of apparently insignificant things, is full of significance." (*Ibid.*, pp. 51-52.) Darwin refused to accept details at their face value.

In view of the Conclusions which follow, and the variety of material accumulated in the sciences, it is not necessary to pass beyond these broad generalities when referring to the established sciences.

PART V.

WORKING STAGE.

SECTION XXI.—PRECISE NATURE OF PROBLEM TO BE INVESTIGATED.

CONCLUSION 14.

Need of Precisely Determining the Nature of the Problem under Investigation.

§ 105. Granting that the question which we desire to address to nature is an admissible one (Conclusion 5) and that its character is also such as to commend itself to the methodologist (Conclusions 4 and 25*d*), it only remains to provide that our interrogation shall be unequivocally formulated. This may be difficult, perhaps impossible, at the very commencement of the enquiry. In that case, little is lost, however, if we are fully conscious of the haze in which our conceptions are enveloped. Many a problem only exists because it is not clearly framed, that is, the mere proper framing not infrequently engenders its solution. Every effort should be therefore made to devise a formulation of the problem which shall be minimally ambiguous,

and which shall consequently enable us to approach its solution with the least possible confusion and delay.

Darwin entitled his master work: "The Origin of Species".¹ If he had called it "Evolution", this would have probably argued that he either regarded evolution as restricted to life forms or that in his opinion all evolution exhibited an exactly similar character. Even if the title had read "The Evolution of Life", "The Evolution of Life Forms", or "The Evolution of Species", we should have been some distance from the plain and exceedingly pointed question involved in the actual title. The word "origin" implies no contentious theories, and the selection of the term "species" brings the problem from the clouds down to earth. Compare this title with Lamarck's "Philosophie Zoologique", which places us at the mercy of the speculative fancy. In other words, instead of floundering in a sea of ambiguities, Darwin's formulation puts us in a position to defend or attack the central problem forthwith.² No doubt, a good title or an appropriate question is mostly the result of protracted labours, and suggests in not a few instances that a mass of intractable matter has been reduced to comparative order. Such an attempt to construct a convenient formula sometimes proves to be hopeless, and is accordingly abandoned, whilst at other times the *quasi*-single problem divides into several, or is solved in the sheer endeavour to state it with the least obscurity of expression.

§ 106. We present another significant illustration. Capitalists as a class contend that they are the source of the wealth of the world, and that the rule of the worker would spell universal economic ruin. On the other hand, Labourists as a class aver that the wealth of the world is produced by the workers, and largely wasted and most unfairly distributed by the Capitalists. To the former, Labourism denotes anarchy; to the latter, Capitalism signifies the social dominance of unscrupulous exploiters. To comprehend the issue, we ought to affix, before proceeding any further, a precise meaning to Capitalism and Labourism. If we regard the problem statically, from the viewpoint of the present moment, both parties appear to be, broadly speaking, in the right. If the Labourist were to be placed forthwith in power, the economic structure of

¹ The idea cannot be said to have been entirely novel, and Wallace uses the expression suggestively. In writing to Bates, the naturalist, he states that he would "like to take some one family to study thoroughly, principally with a view to the theory of the origin of species". (Quoted by Edward Clodd, *Pioneers of Evolution*, 1902, p. 61.) And writing to the same correspondent subsequently, he speaks of gathering facts "towards solving the problem of the origin of species." (*Ibid.*, p. 62.)

² Of course, the full title was *On the Origin of Species by means of Natural Selection, or the Preservation of Favoured Races in the Struggle for Life*. Subsequently this was altered to *The Origin of Species by means of Natural Selection*.

society would most likely collapse and drag down with it poor and rich alike, since Capitalism is the linchpin in the economic wheel of present-day society. At the same time, adhering to the static view, the charge against Capitalism, of insatiable greed, of ruthless exploitation of the masses, of appalling waste, could not be readily rebutted; and it is also true that, for example, if the revenue of England for the past year could be fairly divided between the family groups composing the country, a tolerably adequate income, instead of a pittance, would be assured to all.

The fact is that the vast wealth of to-day is, broadly speaking, primarily the result of the enterprise, the encouragement of inventions and discoveries, the exploitation of opportunities, the alertness and venturesomeness, and the competitive spirit of present-day Capitalism. Manual and clerical labour, as conceived by many Labourists, would leave us in the sorry economic position of savagedom. Machinery, for instance, may enormously increase the value of labour, and organisation on an imposing scale also vitally contributes to augment possessions. Wealth is like a spinning top which continues in its upright position because it is kept moving. Only the short-sighted would argue that the upright position of the top is independent of the motion periodically imparted to it. Without the worker, it is true, the entrepreneur would accomplish nothing; but without the entrepreneur the productivity of the worker would be comparatively insignificant. For instance, it is said that a spinner now produces in a day what it would have taken his eighteenth century forerunner a full year to produce.

However, the problem of Capitalism and Labourism is not one peculiar to our day. To ascertain, therefore, the essential meaning of the terms Capitalism and Labourism we must enter more deeply into the question.

Turning to the past, we find, retrospectively, that Capitalism may be readily divorced from enterprise and progress. At that stage the economic value of the Capitalist was decidedly problematical, and in that case it was as nearly as possible true that wealth is first and foremost the outcome of mechanical labour, since enterprise, competition, and organisation were then a minus quantity practically. On the other hand, if we read aright the signs of our time—the growth of the efficiency and the humanitarian movements, we perceive that the Capitalism of our day will almost certainly undergo radical modification. The employer will probably come to regard himself as an organiser, and be ready to share equitably with the worker the wealth produced, treating him as a fellow labourer. Cut-throat competition, pitiless exploitation, the accumulation of riches, may well be imagined as ceasing to characterise Capitalism. The Labourist, on the other hand, will undergo an analogous evolution. He will learn that wealth has a double

source; he will educate himself; he will become an ardent believer in the need and the potentialities of scientific organisation and efficiency; he will be a brain worker as well as a handworker, a tireless initiator and remodeller, ever aiming at improving processes and products. The Capitalist will thus evolve into an organiser with no superior controlling status, and the Labourist will develop into an individual who, with other individuals, appoints or dismisses the organiser, as shareholders appoint or dismiss a board of directors, and who participates to some extent in management.

As thoroughly democratic governments evolve by degrees out of irresponsible despotisms, so democratic control and management of wealth will gradually succeed the present-day capitalist control and management of wealth. Intelligently to apprehend the meaning of the problem we are to investigate, is in this case also virtually tantamount to succeeding in its solution.

§ 107. Again. Consider a cluster of problems arising out of the World War. It has been argued that since a police force is indispensable in intra-national affairs, therefore a police force is also necessary in inter-national affairs. The case for an international army is thus, in nearly every one's opinion, regarded as conclusively established, indeed so much so that doubt on the point is regarded as a sign of sheer obstinacy. And yet, is there a parity between a police force and an international army? Visualise a London policeman on his beat, his only weapon the truncheon, and his main duty to regulate the traffic, prevent offences, and arrest flagrant offenders against the law. Visualise now the so-called inter-national police, and you find murderous instruments in profuse variety, and no intention to be of use in peace or to arrest flagrant offenders against the law and hail them before a magistrate. The contrast between the equipment and the duties of the intra-national and the inter-national police force is so extreme as to verge on the ludicrous. Manifestly, the connotation of the terms in the two connections diverges radically, and we arrive therefore at the conclusion that if the problem were properly posited, the comparison would be dismissed as fallacious.

Moreover, are we justified in reasoning from individuals to territorial groups, as is done in the last illustration? The police proper is here or there in constant requisition. Are we to imagine that the inter-national police, pursuing the analogy, will be also here or there in constant requisition? Is it not more correct to draw a crucial distinction between individuals and territorial groups? Thinking of the last fifty years, and leaving aside Ireland which has never been truly assimilated, we find that of the thousands of territorial groups of the island kingdom, probably not one has either entertained the idea of attacking other territorial groups or been cowed into submission by the national "police" or army. In other words, the problem

of physical force has literally not arisen for these territorial groups. From this and cognate considerations we may infer that mobile individuals and immobile territorial groups belong to two fundamentally different categories: the one, in modern times, inconceivable without a police, the other capable of existing for centuries, and presumably indefinitely, without even the threat of physical force. An examination of the differences between an individual and territorial groups would show why this is so; but this would lead us beyond the limits of the present Conclusion. Suffice it that since physical force is, one may almost say, never contemplated in intra-territorial questions, its use in inter-territorial difficulties may be conceived as equally unnecessary. Shifting the problem from the margin into the focus, we discover that we are confronted with two astounding, but exceedingly plausible, fallacies. A new formulation hence ensues: "If physical force is not needed in the governance of intra-territorial groups, is it indispensable in the relations of sovereign territorial groups?" Here, too, the historic and evolutionary method—including as it does past, present, and probable future—should be applied.

What, again, shall we say to the suggestion that the armaments of the nations should be limited? Once more we have a popular demand, universally deemed reasonable and feasible. The essential implication in this instance is that armaments are a definite quantity which can be mechanically reduced. A hundred years ago, when inventions played an insignificant part in war and peace, there could have been no grave logical objection to this demand. Is this, however, so to-day? Think of the World War! Germany's first successes in Belgium and France, and the great Russian "drive", were principally due to the unexpected quantity of ammunition and machine guns used, and to the influence of the unanticipated German and Austrian monster guns. Moreover, the U-boat and its fiendish method, as well as poison gas and other potent factors, were novel to the world. Accordingly, if an Armaments Limitation Agreement had existed before the war, it would have almost certainly not provided for these unexpected instrumentalities, and would have therefore left Germany in a highly advantageous military position. It is hence likely that an Armaments Limitation Agreement concluded now, would be very largely obsolete in a decade or less, and prove perilous to nations relying thereon, especially in view of the experience gained during the war and the harnessing of science to the car of international slaughter. Once more, a clear statement of the problem would have shattered a fallacy which is at present almost ubiquitously diffused.

Or, consider the enthusiasm engendered after the termination of the World War by the proposal to form a League of Nations. "We must have a League of Nations", was the cry of all parties, save of the small ultra-militarist group. Yet what precisely is

signified by a League of Nations? One could read for months in the press leading articles, special articles, and cables on the subject, without this fundamental question being asked. Roughly, it might mean an agreement between the leading governments of the world to defend each other if attacked. For the inner circle—a certain number of experts—it was a project involving an International Court whose object it was to *inquire* into *justiciable* cases, and a Council which was to act as mediator, conciliator, and legislator, and some kind of internationalised army. On one point unanimity appeared to exist, namely that a League of Nations would form an effective bulwark against another *attentat* on humanity. Why this should follow, it was difficult to comprehend. Yet if the precise nature of the problem had been determined, the discussions would have been distinctly more profitable. Even the advisability of a League of Nations in any form might have been called into question, and a new issue would have been raised: for example, whether a Legislature, Court, and Administration, with total absence of armaments, was not what existed in intra-territorial affairs, and what should be introduced into inter-territorial affairs? In any case unbiassed reflection would have shown that there was no virtue in a League as such; that a League might be a reactionary body; that a Court restricted in its scope, and confined merely to platonic expressions of opinion, would very likely prove abortive; that a Council of Conciliation, constituted of Government nominees, was a travesty of a democratic institution; and that our age and its spirit demanded nothing more nor less for international affairs than for national ones—a democratic Legislature, Court, and Administration. As a minimum, thinkers ought to have made proposals which were unambiguous, and not proceeded to assume the clarity of an expression which was really vague in the extreme. Now that the League—with its Secretariat, Council, and Assembly—exists, the object of reformers should be to develop it into the positive direction indicated above.

Suppose, again, that the problem submitted is that of the causes of peace and war. Here, unless the terms are properly defined at the initial stage, the investigation may assume gigantic proportions, and yet the results may only darken the issues involved. As explained in § 117 there is almost a universal tendency to think of problems in the light of momentary and local interests, and thus to mistake passing symptoms for eternal verities. A state of war tends therefore to be defined in certain extremist quarters as resulting from any and every kind of social backwardness, and peace as only securable through social conduct which is in every way irreproachable, whilst other extremists reason that, *e.g.*, wars have always been and will for ever remain because demanded by human nature, a period of peace being a transitional stage between one war and another. Along this road advance is manifestly barred.

The clear thinker will be resolved to fix the objective signification of the terms Peace and War, and to seek for real instead of presumed causes. If he sets out with such an intention, he fulfils the demands of the Conclusion.

§ 108. Lastly. Reasoning hastily without fixing the problem, we may be inclined, for instance, to ascribe India's industrial backwardness to such factors as race, climate, tradition, and religion. Yet if we attentively peruse the comprehensive *Report of the Indian Industrial Commission, 1916–1918*, we learn that such a conclusion would be decidedly dubious. The Commissioners find that the intensive industrialism of the West is due to definite causes, such as nation-wide elementary education, lower and higher technical instruction and training, hygienic and sanitary reforms, legislative protection of the worker, facilities for land acquisition and banking, and, above and through all, to Government support and initiative. Accordingly, the Report concludes in effect that the industrial immaturity of India is no greater than would be anticipated in the circumstances of any Western country, and the Commissioners confidently expect that with the necessary reforms realised, India will enter as an equal the comity of highly developed industrial nations. Could one not, we venture to ask, extend the Commissioners' conclusions to all so-called backward peoples and races? Must we not be as definite as the Indian Commissioners before we affirm that an unbridgeable difference exists between one people or race and another in any cultural direction whatsoever?

The frequent failure to define the problem to be solved is not seldom the cause that an enquiry proves comparatively barren, or is unnecessarily cumbersome and protracted. Granted, however, that the nature of the problem under investigation has been determined as precisely as circumstances permit, we proceed to examine the detailed facts through inspection, observation, and experiment. Before doing this, however, we shall consider certain problems allied to the one discussed in this Conclusion.

CONCLUSION 15.

Need of Exact Terminology, of Conclusions in the Form of Precise Definitions, and of Extreme Definiteness in Thought and Statements.¹

§ 109. (A) *EXACT TERMINOLOGY*.—The need for simple, exactly defined, fixed, and universally accepted terms, as well as for a sufficiency of these, is commonly recognised. This topic, however, need not be laboured, seeing the common scientific practice which leaves little to be desired in this

¹ "Everything relating both to bodies and virtues in nature [should] be set forth (as far as may be), numbered, weighed, measured, defined." (Bacon, *Parasceve*.) "Practical working comes of the due combination of physics and mathematics." (*Ibid.*)

respect. We may, nonetheless, stress the point that the terms selected should embody descriptions rather than theories, and that provisional terms should be replaced as soon as possible by truly descriptive ones.

At the same time we should remember the cogent reasons which underlie the demand for a precise terminology. For instance, the technical employment in a treatise of such a term as *nature*, *religion*, or *morality*, generally suggests to the reader ideas diverging appreciably from those in the mind of the writer; and if we add to this that each generation alters its general outlook to some extent, it will be perceived how desirable it becomes that a term shall be unequivocally defined. For this reason mathematical terms are alone truly satisfactory, because it is impossible, or nearly impossible, to misconstrue their meaning. "How much we owe to the possession of names," says Lord Kelvin, "is best illustrated by how much we lose—how great a disadvantage we are put to—in cases in which we have not names. We want a name for the reciprocal of resistance. We have the name 'conductivity', but we want a name for the unit of conductivity. I made a box of resistance coils thirty years ago, and another fifteen years ago, for the measurement of conductivity, and they both languished for the want of a name. . . . We shall have a word for it when we have the thing, or rather, I should say, we shall have the thing when we have the word."¹ John Stuart Mill remarks on this subject: "Hardly any original thoughts on mental or social subjects ever make their way among mankind, or assume their proper importance in the minds of even their inventors, until aptly-selected words or phrases have, as it were, nailed them down and held them fast."² (*Logic*, bk. 4, ch. 6, § 3.) Yet unless the terminology proposed (assuming strict and correct definition), especially in a new science, is indubitably appropriate, or differs but slightly from that in common use, it stands in danger of being disregarded, together with the facts indicated by it. Indeed, from the standpoint of the popularisation of scientific facts, a truly consistent methodology will demand that terminologies and nomenclatures³ be not derived from foreign tongues,⁴ for this creates immense and yet quite un-

¹ The science of Sound is seriously hampered through lacking a term intermediate between "noise" and "harmony". Similarly, an intermediate term is needed between "tragedy" and "comedy".

² Formulæ and notations are important extensions of the above. They should express the greatest practicable number of facts or relations in an unequivocal manner.

³ "A nomenclature of a science is a collection of names of groups. A terminology is a collection of the names (or terms) which distinguish either the properties or the parts of the individual objects which the science recognises." (Fowler, *Logic*, vol. 2, p. 92.) See, further, on this subject Boyce Gibson, *The Problem of Logic*.

⁴ The obstacles alluded to in the text might be made considerably less formidable by dictionaries comprising an etymological section where words

necessary embarrassments, and that the language, as in the case of Greek, be so constructed or re-shaped as to permit of an easy joining and fixing of terms and part terms. Already academies and learned compilers of dictionaries have contributed appreciably to making language less amorphous and more reliable; but, to attain this end completely, it requires the employment of a method of automatically fixing the signification of words and readily augmenting or lightening the vocabulary.¹ Till that day arrives there is perhaps some advantage in employing for scientific purposes the words of a dead language not subject to the disastrous wear and tear of daily use in the irresponsible market of the world. If this be so, everybody should learn that language, although nobody should speak or write it (which is virtually the case with Greek to-day). This is, however, a clumsy and desperate device of overcoming what in many languages is now a serious obstacle both to research and to its popularisation.²

§ 110. (B) EXACT CONCLUSIONS.—As with terms, so with conclusions. Lack of precision in great measure invalidates them. To venture therefore in a desultory manner on innumerable assertions concerning a subject, may be arresting because of the very vagueness, but is not exactly enlightening. In consequence, next to aiming at precise terms, we should endeavour to reach precise and truly comprehensive definitions which shall summarise an enquiry in a convincing manner. Such definitions will alone enable us and others to test the correctness of our results and to utilise them for deductive ends, for which reasons they are indispensable. Leaving aside the various definitions of methodological terms which we have offered in Part II, we may further illustrate our meaning by calling attention to the comprehensive definition regarding the nature of man furnished in Conclusions 13 and 34. One might similarly, though tentatively, gather up the total meaning and content of the science of ethics, by speaking of it as “that branch of the general science of specio-psychics which deals with the historic tendency of human impulses, individuals, groups of individuals, and groups

derived from identical roots are classed together. That is, what we attempted to do for English words developing out of the Latin “*vertere*”, in Conclusion 20*d*, might be effected for the whole vocabulary, including prefixes and postfixes. The mastery of the etymology of at least the more common words of foreign origin would then involve a comparatively modest effort which might not be beyond the capacity of the older scholars in the primary school and of adults generally. Not only would novel combinations be thus readily comprehended, but the current vocabulary might be increased, say, to the proportion common in literary works of distinction.

¹ For a project of a scientific language, see § 205.

² The definition of a term may be verbal or real. In the first instance, we merely explain how we propose to employ a term; in the second instance, of which alone we speak in the text, we strive to define the nature of the phenomenon implied in the term.

of human groups, increasingly to satisfy human nature through co-operation"; and one might join to this the practical deduction "until, in the place of the unreasoned need of the moment, which almost exclusively dominates the individual in the first stages of human development, the ideal of the complete and correlated solidarity of the self and of mankind rules undisturbed in man and human nature is completely satisfied". The value of aiming at, and reaching, comprehensive definitions of this character can scarcely be exaggerated. We must become again, but on a higher plane, dialecticians and scholastics. Moreover, the wholesome caution and thoroughness involved in the framing of definitions, point to their being imperative throughout every stage of an enquiry, more especially for deductive purposes.¹

§ 111. (C) DEFINITENESS IN SCIENTIFIC WORK GENERALLY.—Similarly, this tendency towards definiteness should throughout stamp the activities of the man of science, because without it there can be no decisive advance, and since confusion is an even deadlier foe to truth than error. A famous example of definiteness in method, which has been often quoted, is that of the discovery of the manner in which dew is deposited on plants. For over half a century, till 1885, Wells' theory was thus not only accepted but admired. Yet the fact that plants differed from all non-living objects in that they were animate and that they were normally rooted in the ground, was uniformly overlooked—a significant illustration of the absence of a rigorously scientific method of enquiry in our day. This was, of course, more pardonable in older writers. Van Helmont (born 1577) thus reasoned that plants obtain all their constituents from water. In proof he cited an experiment of his own. He had planted a willow weighing 5 lbs. in 200 lbs. of earth. After 5 years the willow weighed over 169 lbs. and the earth had only lost 2 ounces. Ergo, he reasoned, roots and wood are transformed water. The transformability of the all-enfolding air had necessarily escaped his attention.

The advance of science is distinguished by greater knowledge leading to greater definiteness—*e.g.*, "the molecule has been raised from a conception only realisable experimentally in mil-

¹ The following definitions may prove useful. "A fact, in the scientific sense of the word, is the close agreement of many observations or measurements of the same phenomena." "A class, in the scientific sense of the word, is a plural number of facts that resemble one another in some given point or number of points." "A generalisation, in the scientific sense of the word, is an affirmation that a constant relation exists between an unvarying class of facts and some unvarying fact not in the class, or between one unvarying class of facts and some other unvarying class." "A law, in the scientific sense of the word, is an affirmation of a constant relation between a fact of variation and some other fact of variations, or between a class of variations and some other class of variations." (F. H. Giddings, *Inductive Sociology*, 1901.)

lions to the rank of a definite particle whose entry into our apparatus produces a definite and measurable effect.” (James A. Crowther, *Molecular Physics*, 1919, p. 1.) A historical instance is also that relating to scurvy. Green vegetables having been found to be a specific in its prevention and cure, men neglected to notice that long cooking or complete drying destroy the anti-scorbutic factor in the vegetables, just as they tacitly inferred that lime-juice, being acid, may be substituted for lemon juice, a disastrous *non sequitur*, since the anti-scorbutic factor is not to be identified with acidity and since lime-juice contains that factor in negligible quantities only. Likewise, whilst the fertilising agents in animal manure may be detected and artificially produced or found in other substances, animal manures may yet have their distinct value. So, too, unemployment, strike, lock-out, and especially industrial accidents statistics, only became definite and truly comparable when they were presented in terms of days lost, and wages only acquired a definite meaning when they were related to the cost of living for a family of five, and when the minimum requirements as to food, etc., were scientifically ascertained. Similarly the contention, as by Lord Leverhulme in his work *The Six Hour-Day*, that modern industrial methods have increased productivity a *hundredfold* would probably be modified to a modest *tenfold*, or *fivefold*, increase if the actual changes in productivity were definitely envisaged.

§ 112. Indefiniteness is at present the bane of social investigations. Here is, for example, the extremely important sex problem. How simple and natural it would be to scrutinise closely the facts, and, once for all, to sweep away at least the grosser misconceptions on the subject! Yet we have a formidable and ever swelling literature, dealing with one aspect or another of the sex problem, but frequently throwing scarcely a streak of light on the main issues involved. Some few facts here and there have been observed or mal-observed, and forthwith a pamphlet or book is written. For instance, in the high interests of morality scores of publications have appeared which advocate sex enlightenment. Finding that the young stumble over the physiological relation arising out of marriage, ingenious solutions of the difficulty have been propounded. To ensure a sense of purity and a high ideal of marriage, the children should be made acquainted, it is maintained, with the lives of flowers and, more especially, with the general process of the fertilisation of plants. This, bolder reformers supplement with illustrations of the generative processes in fishes and some of the other lower animals, and the most daring delicately encourage the children to observe for themselves what the farm and the street offer in this respect. Still others furnish accounts of the organs of generation in human beings. Only few, however, have the temerity to approach the subject of human paternity. Such

enlightenment as has been indicated above is deemed by many not only urgently desirable, but entirely satisfactory, in that it is said to suffuse the hearts of the young with a feeling of the nobility and sanctity of their body and of marriage. Incessant and mournful are therefore the complaints that parents and teachers as a body cannot be induced to communicate this life-giving information to their charges.

Yet if reformers had not hastily rushed to deal with a fugitive symptom, if they had definitely faced the problem as such, they would have been spared mortification. They should have asked themselves, What is the meaning of *human* marriage? and should have sought a clear answer to this question before thinking of remedies for one or another related social disease. It would have then transpired that it is monstrous to imagine that a study of the farm-yard, or of the fertilising process in flowers and the like, should be conceived to be a fair and adequate introduction to a true conception of marriage. Examining a number of unions of the type which they could commend, reformers might have deduced the subjoined conclusions, among others:—

(1) Two human beings, man and woman, each of about the age of twenty-five, after having felt for perhaps some years that they appreciated, understood, and loved each other, agree to marry and cohabit for the remainder of their lives as lovers and comrades, and, if fortune does not frown, as parents. This agreement they have socially ratified and sanctified by the law, or by their religious organisation, or by both.

(2) Since any children born to them should be as healthy as possible, the parents should be fully developed physically. This stage is reached about the age of twenty-five, and marriage therefore should not be contracted before that period.

(3) The child, when born, is altogether helpless, and therefore to bring offspring into the world without taking care of it after birth is to doom it to almost instant death. If marriage involves, as a rule, the birth of children, the children thus born demand parental devotion for a long period, perhaps even to adulthood.

(4) Moreover, whereas with animals the process of rearing offspring is almost entirely a matter of physical care, with human beings the substance of all moral and other inventions and discoveries made during the history of the race has to be transmitted by teaching to the offspring. This entails, therefore, an incalculably great extension of the responsibilities of human parents. Accordingly, there should be also a solid preparation for marriage on other planes than the physical, if our specio-historic heritage, which alone makes us truly and distinctively human, is to be transmitted to the coming generation. This preparation comprises a high development of the general intelligence, the attainment of a lofty moral standard in conduct and

insight, the due appreciation of what is beautiful, the thorough acquisition of a suitable vocation, a fair understanding of life or the "world", the assimilation of the chief virtues demanded by the intimate common life of husband and wife, sufficient and practical knowledge of the education of children in the home, and training in domestic economy generally. Such a preparation is requisite if marriage is to achieve its significant ends; and this process of preparation, like that of physiological maturing, necessitates that those who are to be married should have reached man's and woman's estate—that is, about the age of twenty-five.

(5) If the children are eventually to become personalities and cultured, both parents should be personalities and cultured.

(6) This implies a feeling and an acknowledgment of equality between husband and wife.

(7) Intimate co-operation between the parents would be also impossible unless a sense of comradeship prevailed.

(8) A life task of such magnitude as human marriage, presupposes, of course, mutual and deep devotion between the partners in marriage. With the above demands satisfied, the flame of love, once it has been kindled, is easily kept alive. Love is indispensable in every arduous enterprise—in elevating offspring, in social causes, in serving one's country. At the same time, sustained love becomes almost an impossibility when life is not rationally organised, and where there is no adequate preparation for the state of matrimony.

(9) Marriage fulfils the universal, or all but universal, desire for a home—for a place and a world which one can claim as one's very own, since mother, father, and children are one.

(10) Whatever be the attitude of the world, whether it is appreciative or contumelious, there can be no greater boon than to have a life companion—another self—with whom one can confidently consult in every emergency, however intimate the matters might be. What parents are to children, parents are as truly to each other in respected families. This form of marriage postulates, consequently, the indissolubility of the marriage tie under all save the extremest circumstances. A marriage lightly entered into, or lightly regarded or dissolved, is no genuine marriage at all. A form of marriage restricted to a certain period, would imply absence of real intimacy—the quintessence of marriage.

(11) In a typical marriage of the best type it is generous ideals, including mutual love and respect, which govern decisions, the individual conceiving himself or herself as the servant of an idea, and not as the ruler or exploiter of another.

(12) If the meaning and the implications of marriage are such as we have sketched above, the well-nurtured youth and maiden will look forward to marriage with a sentiment akin to sacred awe and joy. They will be pure in spirit, and therefore pure

in word and deed. Again, after they are married, infidelity in any sense will be inconceivable to them. Indeed, chastity and fidelity will signify to them respect for all that is implicit in marriage and in *human* nature.

(13) Culture being that ingredient in every human being which stamps him as human, both sexes will regard each other primarily as human, and not as sex, beings.

(14) In conclusion. The truly typical human marriage is world removed from the truly typical animal union—without making any aspersions on the latter, and the propagative instinct has in man a limited and quite definite object to serve. Once this is recognised and conceded, parents and teachers will not find it difficult or embarrassing to introduce the children to the manifold meaning of marriage. On the contrary, this task will become a cardinal one for parent and teacher alike, and its fulfilment will repay a hundredfold the efforts made.

Having acquired a definite conception of the meaning of marriage as a starting point, the problems of home and school education in relation to sex may be approached with confidence, since the physiological aspects have been justly relegated to the background. Nevertheless, or rather just because of this, there should not be the least hesitation in the parents describing to the young the processes of conception, gestation, parturition, recovery, and lactation, thus leaving only for later treatment the stage immediately preceding conception. No young child but would be grateful for such information, and be very much the better for its possession. No parent could hesitate to impart such knowledge. To the young child, it should be remembered, all things are pure.

Much mischief has been caused by assuming that at the age of puberty the minds of the young are suddenly perturbed and absorbed in matters of sex. Leaving aside sophistication through, *e.g.*, perverse companions and morbid literature, nothing seems further from the truth. On the contrary, as we might expect, the whole nature is opening out towards adulthood with its innumerable phases. Cricket, football, the desire to be a sailor, travel or hunting, keenness to become independent and prepare for some vocation, notions of reforming the world, adventures and new experiences generally, thoughts of maturity, such is the adolescent's programme. Interest in the complementary sex enters only later and, save for exceptional cases and causes, scarcely captivates the mind of the semi-adolescent. The adolescent desires to develop and assert the whole of his many powers. In fact, if this were not so, the adolescent would reach adulthood pitifully unprepared and entirely unfit for the tasks of life and marriage. The alarmists—those who hint that with puberty should come satisfaction of the sex instinct, and those others who contend that with the advent of puberty should ensue a desperate struggle to curb and crush the rebellious sex

instinct—should be converted to a saner view of adolescence, a view in closer conformity with fact and the distinctive nature of man.

After home and school enlightenment, follows the education of young men and women, and finally that of adults and of married folk. Here also a definite conception of the meaning of marriage should render impossible the crude, revolting, and unnatural views which so widely prevail, views portraying men as miserable weaklings incapable of self-restraint and women as the willing slaves to men's lusts. The psychology of the whole matter requires to be assiduously examined. For instance, it appears probable that much sex thought is incidental to the general process of falling into a certain habit of thought and is moreover normally unconnected with sex feelings, and that sexual aberrations are to be primarily explained as matters of depraved thought habits, and not as resulting from perverse sex instincts. Likewise, in an individual who has not been socially drilled into sex emphasis, bodily sex feelings may be present and yet not issue into sex thoughts of any kind—which should be the normal experience. Again, bodily sex disturbances during sleep should not normally result in sex dreams, and where they do, it should be remarked that the dream is most frequently an attempted interpretation and not the cause. It is also worthy of consideration that sharply turning away the attention commonly wipes out any line of thoughts, including sex thoughts, and that turning the attention intently on any bodily sensations, including sex sensations, has the same modifying effect normally. In a word, there is no justification for assuming a kind of fatal connection between sex thoughts and sex feelings, and *vice versa*. Perhaps most important of all is the psychological effect of a true conception of marriage both before and within marriage—a conception restricting sex intimacy to the perpetuation of the race, and the fact that sex demands are freely diminished or heightened by the law of habit.

Thus a really definite conception of the meaning of marriage, a clear apprehension of its total meaning, may lift many out of the morass into which they have sunk.

§ 113. Or consider the human problem *par excellence*, that of conduct, from the point of view of definiteness of thought. Preachers and prophets throughout the ages have vied with one another in lamenting the hardness of men's hearts, their ethical obtuseness, and their disloyalty to the moral law. Especially painful has been the almost universal impression that belief in the ideal, on the one hand, and its realisation in our conduct, on the other, are apparently diametrically opposed to each other, so much so that it has been widely surmised that men and women are by nature corrupt, and therefore incapable of obeying the behests of the ideal. Yet definiteness of thought, or facing the problem as a whole, would have dispelled this

paralysing despair and these corrosive suspicions concerning a fundamental characteristic of human nature.

We perceive, for example, that it is one thing to say to oneself, "A man should stand erect, not be held erect by others", "Pass your life in honesty and purity of heart", "Be master of your appetites", "Be perfect", and quite another matter to realise these maxims in our conduct. Yet why should any one be surprised at this? Suppose we said to those who desired to paint beautifully, or to those who wished to be athletes, "Be ye perfect", should we consider it just to expect that forthwith there should stand before us perfect painters or perfect athletes? Yet where lies the difference? The ordinary man—would-be painter or lover of the right—has many firmly rooted habits to extirpate and many new habits to plant and tend. Neither to exaggerate nor to understate, to place oneself in the position of another, to become self-reliant, to feel kindly disposed towards all whatever their character, to be alert in order to perform some good act, to assume complete and easy control over our bodily desires and long-established habits, to display delicate insight into the needs of others, and much else that a live conscience exacts, manifestly requires minute adjustments which only long, deliberate, and experimental practice can properly effect. Not a line can be written about the methods of acquiring an art, which does not apply to the art of conduct.

We learn, accordingly, that absence of definiteness in thought, *i.e.*, of a proper perspective, is the cause of men and women falling far short of their ideal and being in incessant conflict therewith. Let the art of conduct become a genuine art, and let children from infancy onwards be systematically trained to develop all the virtues pursuant to the law of development in all the arts, and we shall have a right and a reason to anticipate lives where the ideal and the real almost meet.

§ 114. Or let us probe the question of peace and war by means of the test of definiteness. It is a common argument, sometimes urged with regret, that war, like penury or vice, has always existed and will consequently, it is alleged, continue for aye. If we definitely ask ourselves, however, what war is, this depressing conclusion seems by no means self-evident. For instance, erstwhile private war or revenge was universal, and yet in the most civilised lands lawlessness has virtually passed away. Again, towns and provinces were formerly often at war, whilst nobles boasted of their retainers and fought one another—a condition of society now wholly obsolete. Small countries frequently at war with one another have been fused together and have become large countries, *e.g.*, England, Germany, Italy, the old feuds never recurring. It is, therefore, manifest that with the growth in humaneness, the granting of personal and corporate autonomy, and the integration of international relations, the time must arrive when

the nations will be bound to each other by innumerable ties, when an inter-national parliament and administration will be established, when inter-national courts of law will possess the status of our national law courts, and when war between nations will be as inconceivable as war between towns. In fact, as intra-national consolidation proceeds, war is abolished within the nation, and when the relations between different countries will have been consolidated, war will have ceased altogether. Such considerations evidence that those who believe in the lasting continuance of warfare fallaciously postulate, because of indefiniteness of thought, that feuds have only occurred between nations and that the closely cooperating nations of the future will be reflexes of the practically self-contained nations of yesterday. Viewing the problem, therefore, in the proper perspective, we learn that war is bound to disappear.

§ 115. Or, again, study the problem of the abolition of poverty. To read any of the many inspired and inspiring utopias, one marvels that they have not been realised long ago. We have only to socialise the means of production and of exchange, so the story runs, and everybody will possess more than sufficient of the good things of life, whilst his or her hours of labour will very nearly reach the vanishing point. The plan is so enticing that it should not even meet with the opposition of the rich who assuredly demand no more than a superabundance of desirable commodities and an ample allowance of leisure, and still we do not appear to be approaching the sanctified soil of the promised land. The fact is that definiteness of thought is wanting in many of our social reformers. The well-to-do perceive no prospect of obtaining more than they need in the socialist State, and therefore seek to frustrate its advent. As we point out in Conclusions 6, 17, and 20, with the views current as to how material satisfaction is to be obtained, the socialist State must inevitably fail. It cannot offer each individual £50,000 a year, or its equivalent in kind, nor permit him to draw up his own time table, nor provide each person with a small army of secretaries, stewards, butlers, lackeys, valets, housemaids, cooks, gardeners, chauffeurs, and other attendants. So long, in fact, as men think as they do at present concerning the sources of happiness, they would seek to exploit the socialist State as they do the contemporary State, with the inevitable result that the socialist State would deteriorate no sooner than it was instituted until it reached some condition of disequilibrium resembling the States of to-day. It is of no avail for the worker earning two pounds a week to protest that he will be abundantly satisfied when he is in receipt of what may be valued at six pounds a week. He nurses an illusion, as the social facts prove, for in our day each class, whatever its income, seeks as a rule to "better" itself. The minimum required for arriving at the beatific state presupposes

therefore a true conception of human nature, true insight into what constitutes a satisfactory life, and, furthermore, a moral enlightenment and training which shall render it easy for men and women to live in the light of a high ideal. Granted these, we should possess a basis for the socialist or social State which would resist all onslaughts, and we could, and would, confidently and cheerily labour for its speedy—or rather more complete—realisation. Lack of courage to face the problem as such, and an insistence on what is transient, are the undoing of those who seek happiness in wealth and those who work for an era

"When wealth no more shall rest in mounded heaps,
But smit with freer light shall slowly melt
In many streams to fatten lower lands." *(Tennyson.)*

These remarks, however, are by no means intended to discourage the disinherited from looking forward to a socialised State, and from demanding at present what they abundantly deserve as their due—an adequate living wage, shorter hours, full employment, hygienic workplaces, respectful treatment, and better conditions of labour generally.

§ 116. Finally, there is the engrossingly interesting problem of the nature of religion. Many thinkers not only restrict the meaning of the term to their own creed, but limit it to their particular interpretation of that creed. So, too, the term is said to connote the existence of a supernatural and infinite deity, or at least of deities. On the other hand, there are those who speak of a religion of health, a religion of art, a religion of love, a religion of goodness, or who identify religion with some aspect of some religion or religions—worship, devotion to an ideal, and the like. Only a firm resolve to reach the core of the meaning, a desire to be quite definite, to be quit of delusions, can aid us here, as in social problems generally.

If, in this spirit, we analyse various religions, we discover that he who is religious feels that he needs assistance such as he does not find in himself or in his immediate environment, or requires at least to be reassured concerning the rational and moral constitution of his world. In the earlier religions, even to the time of the Romans, living men, it is true, were also sometimes worshipped, but on the understanding that they were not like other men, whilst in these latter days many individuals, most of them well favoured by the fates, have been satisfied with the existence of a deity who had arranged from eternity everything for the best. In either case self-containedness is excluded. In Judaism, Christianity, and Moham-medanism, the individual regards himself as in a desperate plight but for the support of his deity, and but for the assurance that his deity watches over mankind. Buddha, it is said, came to save men from themselves and their miseries by means of his discovery that they could rise superior to

their destiny, by passing into the state of Nirvana, beyond the realms of sense and thought, or at least beyond the reach of selfishness into the elysium of altruism. Zeno, touching the very heart of the problem, taught how the rational or distinctive element in man might rule the animal element of the passions and the appetites. Confucius found in the study and reverence of antiquity, with its moral treasures, release from spiritual and moral bondage for his people.

Summing up the matter, we observe that, for certain reasons, the individual distrusts his powers. He asks himself What is the meaning of my life? Is the good life really more satisfactory than the bad life? Is there an uncertain struggle between evil and good, or will justice triumph? Is there any help for me, here and now, in my anxieties, or have I only myself to rely on? Am I to obey or to control my capricious impulses? In a word, allowing for varied stages of social development and experience, the individual desires to feel "at home" in the world, and is convinced that this feeling can only be his if support be forthcoming beyond that which self-reliance or his fellows about him can proffer. He needs a cheerful and bracing philosophy of life, an assurance that he does not stand by himself and that the right shall not be mocked. Sometimes, as Lucretius points out, the philosophy of life believed in is neither very cheering nor very bracing, but it is probably the most cheering and bracing within reach. Whether the solution proposed be natural or supernatural, magical or scientific, is indifferent to the fundamental problem of religion. So long as the individual feels that he needs support beyond what he may anticipate from his neighbours, a religion will be to him a necessity, the particular form of the religion being a secondary matter, save in so far as the demand for a cheerful and bracing philosophy of life is well or ill satisfied.

Definiteness or comprehensiveness in thought thus leads to a definition of religion which in all probability is substantially correct, and which may aid us in distinguishing that which is religion from that which is not.

The same method may help us to proceed a step further. Is the central fact of all religions—the individual's alleged self-inadequacy—established by science or not? The mere fact of the existence of religions at all periods makes the supposition eminently plausible. However, throughout this volume, and especially in Conclusion 13, we have seen that, considered from a purely scientific standpoint, the individual as such is virtually a zero. No religion, therefore, can make the isolated individual appear more impotent than science proves him to be. The religious craving has consequently an indisputable foundation in reality. But what of its object—the existence of a power which is to re-assure him? Can science discover any verity corresponding thereto, or propound any cheering and

bracing philosophy of life? Here we are face to face with a new problem, inasmuch as the various extant and extinct philosophies of life have been parts of widely diverging systems of thought. Yet one may be permitted to surmise that it cannot be a sheer coincidence that in the conception of humanity as developed in Conclusion 13, we are offered a philosophy of life intimately corresponding in all its essential outlines with the older religious conceptions. That is, in humanity—embracing past, present, and to come—we discern a verifiable entity possessing virtually all the attributes of the traditional deity—practically infinite goodness, wisdom, power, and omnipresence, and incorporating a cheerful and bracing answer to the commanding questions which lie at the heart of religions.¹ We learn, accordingly, that religions have always been justified psychologically and practically, and that modern science hints at a philosophy of life closely corresponding in principle to the older religions, but excelling them in geniality, helpfulness, and energising power.

§ 117. In the problems in this Sub-Conclusion we observe that *the interest of the social reformer centres as a rule in the vanishing point of what is momentarily and locally felt and experienced, instead of in the multiple, massive, and enduring fact of which the former is but a single and transitory manifestation*. We have thus abundantly proved Bacon's fundamental contention that what is regarded as obvious does not disclose, but masks, reality, and that the enlightened seeker after truth and the alert social reformer will invariably endeavour to pierce through the cloud of contemporary commonplaces and crude surmises by applying the methods proposed in Conclusion 19 *m*. He is indefinite in his thought who, in doctrinaire fashion, blandly assumes that he need not go behind superficial symptoms or beyond unexamined current hypotheses, or who, in other words, capriciously regards a fraction of an organic whole as an independent entity. We repeat. The layman cannot be expected to probe to the kernel the legions of theories recommended to him; but of him who specifically devotes himself to a cause or truth we have a right to demand that he shall examine the whole ground on which he stands and not only a fraction thereof.

§ 118. (D) DEFINITENESS IN STATEMENTS GENERALLY.—In present-day France, lucidity in expression has been virtually carried to the stage of perfection. Other things being equal, it will be agreed that the power of unequivocally communicating our ideas in words, is not only of benefit to him who hears or reads, but both prevents our thought from being confused and our statements reacting disastrously on our ideas. Methodological procedure, that is, demands that our cogitations shall be clear as a crystal stream, and that our

¹ See G. Spiller, *Outlines of a New World Religion*.

language, which is to reflect our cogitations, shall be equally perspicuous. Moreover, clarity of expression should not be the outcome of painful toil, of a tortuous approximation to an ideal of style through the medium of ceaseless emendations, but the result of efficient training in earlier years. Else the actual research work is impeded and interfered with, if it is not seriously contracted and its quality materially depreciated. The ripe thinker, in other words, should no more need to impart clearness to his style by the sweat of his brow than be anxiously concerned about his spelling and grammar.¹ Clarity of expression will, finally, react on language itself and permit the allotting of definite meanings to definite articulate sounds, without the apprehension that familiarity will breed contempt, or that the words will be employed carelessly and be in this way degraded and lose their definiteness.

SECTION XXII.—OBSERVATION.²

§ 119. It is difficult to ascertain and examine the exact fundamental facts underlying the process of observation as such. We might, however, state that there needs to be some circumscribing concept guiding us in our examination, that is, we should search for similarities of a certain order and exclude all other classes of similarities. If it is a question of the definition of a chair or table, for instance, we seek for general similarities, and we neglect all special or individual ones, such as material, colour, size, precise conformation, or ornamentation. In fact, we always presuppose in investigations a general classification of phenomena, and endeavour to find similarities in accordance with that classification. (See Section V, also Conclusion 3.) For this reason, anything we can say in this work on the subject, can only be in further elucidation of the recognised mode of observing. Granted, then, a general preparedness and a special object, we assume that in observation we seek as a rule for intrinsic and important resemblances in a group of individuals, and that we strive to divide this group into as many important groups as possible, or merge it into a wider group. We examine in this way a large assortment of individual objects, and, having noted their features, we class

¹ He who is, broadly speaking, perfectly educated will have a perfect command of the whole of the non-technical vocabulary. This in itself will clarify thought and effectively aid in clarity of expression. A danger should be, however, guarded against, that of being fascinated and satisfied with clearness as such.

² The term Observation, in this Section and throughout the treatise, is intended to include the term Examination—observational and experimental examination of physical and psychical objects, processes, and forces, of propositions and proposals, of historical and other documents, of trains of reasoning, of terms, of formulæ, of statistics, etc.

them together or apart according to their substantial resemblances or divergences, not, however, without re-examining the facts and finally formulating the shortest practicable comprehensive statement. Nevertheless, in many instances our interest may be to fasten on divergences rather than on resemblances, in which case we search for heterogeneity rather than for homogeneity. These few preliminary remarks must suffice, as our object in this Second Book is practical and not theoretical.

CONCLUSION 16.

Need of applying the Categories; of Strenuous Mental Application in the Process of Observation; and of the Observations being Graded, Comprehensive, Important, Numerous, Full, Rational and Relevant, Original, Automatically Initiated, and Methodically Developed.¹

§ 120. (a) *Utilisation of the Categories.*—The purpose of Observation is, mainly, by the application of the third table of the Primary Categories to ascertain circumstantially the Material and Modal Aspects of a phenomenon, as enumerated in the first and second tables of the Primary Categories. That is, the investigation will not be guided by chance suppositions varying with occasions and inquirers, but by comprehensive tables covering virtually the whole extensive ground. This method should compass a gigantic saving of effort and secure the reduction of incomplete or erroneous results to a minimum. At the same time certain peculiar or special procedure aspects need to be emphasised in relation to observation, and this we are essaying in the subjoined paragraphs.)

§ 121. (b) *Concentration.*—In observation, as in all forms of mental activity, we should *intently concentrate*² all our faculties, and avoid both over-confidence and over-anxiety. Mechanical or routine observation is unscientific. (§ 154.)

§ 122. (c) *Point of Departure.*—*Facts of perception* should form the point of departure of an investigation.

§ 123. (d) *Direct and Original Observation.*—Observation should be *direct*, or *original*. "Learn all things as much as you can at first hand." (Watts, *Logic*, p. 73.) Occasional recollections, oral accounts, pen descriptions in books, drawings, paintings, models, and the like, should be only utilised when observation, external or internal, is impracticable, or when the accounts issue from a scientific source or are employed for comparison. It needs scarcely stating how frequently scientists pass deliberately and critically over ground which their fellows have trod.

¹ For the full meaning of these adjectives, see Conclusion 25.

² Darwin "assigned supreme importance to the habits of incessant industry and concentrated attention. . . ." (Frank Cramer, *op. cit.*, p. 17.)

It may not be out of place to supply a graded series of cases for the purpose of elucidating the full signification of direct observation: (1) Some one has completed a direct, extensive, historical, and exhaustive study of the nature and habits of sheep; (2) he has had frequent occasions to observe and study sheep in their appropriate surroundings; (3) he has casually seen sheep on the hill slopes; (4) he has seen one hustled through his street; (5) he saw once a stuffed sheep in a natural history museum; (6—13) he has seen a large (small) coloured (uncoloured) model (picture or print) of one or more sheep; (14—17) he has read (heard) a full and accurate (short and inaccurate) description of sheep; (18—19) he acquired his information a long time ago from vague hearsay about sheep, and cannot, besides, trust his memory. It is manifest that a very appreciable difference exists between (1) and (19), and it is to be deplored that outside recognised scientific research in the physical and biological sciences, there is no adequate apprehension of the need of keeping closely to (1), whilst a tendency exists to look indulgently on (18) and (19).

Owing to what seems an unconsciousness of the necessity of examining facts at first hand and thoroughly, a century of continuous movement in the sphere of psychology has yielded no conspicuous fruits. The proper nature of the principal divisions of the mind, even pleasure-pain and the sensations, are to-day no less and no more known, one might almost say, than they were a hundred years ago. The views of the psychologist, as his terminology evidences, have remained in essence those of the man in the street. This disregard of the rule of turning directly to the facts and of challenging the scientific value of pre-scientific classifications, has been powerfully promoted by the belief that effective introspection is impossible—a belief grounded on speculative considerations and on the experience that *beginners* find it difficult to introspect impartially or well,¹ as they would find it difficult to do ANYTHING impartially or well. On this account an eminently simple science,

¹ For instance, it has been said that we cannot examine the conditions of fear and other strong feelings, when what should have been stated is that we cannot examine directly the first moments of a fierce passion. Or it has been contended that we cannot attend to what we are attending, when we are engaged on this the whole day almost. Or it has been argued that introspection only refers to one individual; but it has been forgotten that that individual lives for many years and must of necessity reflect the most general laws of mind. Here is a comparatively recent statement pertaining to the alleged drawbacks to introspection: "Analytic observation of mental processes is difficult just because they are processes and not fixed, enduring objects. We cannot examine at leisure and again and again the same mental process; for, as we try to notice its peculiar quality and complexity, it changes every moment, and it can never be perfectly recovered or restored; and it changes, or rather gives place to another process, all the more quickly, just because we direct our attention to it." (W. McDougall, *Psychology*, 1912, p. 46.)

unlike that of physiology or medicine, has made no progress worth remarking for several generations, solely because the primary facts were not adequately investigated.¹

The case of the science of ethics is, in one respect, even less satisfactory, for whereas the social factor necessarily complicates matters here to a notable degree, almost the only promise we have yet of this department of knowledge is the academic name. Those who have made a faithful study of this nominal science, can scarcely call into question that theory plays in this science a prodigiously greater part than fact. Here also the irrelevant views of common sense and scholasticism are triumphant. One vainly searches for a systematic treatise telling of the various notions men and women entertain, and have entertained, on morals; of the relative place morals occupy in life and mind, and their relation to other parts of life and mind; of experiments to test their genuineness, scope, and limits; of the nature of the good man, and of the signification of ethical terms; of the development of morality in children and also in institutions, such as charities, hospitals, schools, prisons, etc., etc.—all performed in a thoroughly impartial and scientific spirit, with an eye to pristine fact and not to prevalent or ancient theories and philosophies.²

§ 124. (e) *Accuracy*.—Scrupulous accuracy as to constituents, form, quality, quantity, time, place, degree, state, changes, and the categories generally, should be aimed at in observation, and on this point the present generation of men of science has become almost preternaturally sensitive—with magnificent results. Accuracy prevents endless complications, and saves, therefore, much time and thought. Thus he who concluded from his observations that each expiration emptied the lungs of air and each inspiration filled them with air, or that the expelled air had lost all its oxygen, would gravely misrepresent the facts.

Faraday's infinitely precious rule should guide and inspire the observer that no need should exist for repeating an observation or experiment, and we should ever recall that Darwin "saved a great deal of time through not having to do things twice". (Frank Cramer, *op. cit.*, p. 29.) The accuracy should also extend to the statement embodying the observations, and for the same cogent reasons.

¹ The present writer has attempted in his *Mind of Man* to deal with the nature of the human mind, apart from tradition and on the methodological lines sketched in earlier drafts of this volume.

² In a recent work treating of the methods employed in the sciences, and consisting of contributions by eminent specialists (*De la méthode dans les sciences*, 1910), M. Lévy-Bruhl examines the methods of ethics, and arrives at the conclusion that not even the beginnings of a science of ethics exist as yet. In regard to the methods to be employed in ethical enquiries, see the author's "De la méthode dans les recherches des lois de l'éthique", in *Revue philosophique*, January, 1905.

The following are some of the conditions contributing to a high degree of accuracy:—

(a) Being exceedingly well acquainted with one's material and the means of manipulating it.

(b) Being assured that one's senses (including aids like eye-glasses), memory, nerves, strength, etc., are "normal"; that instruments and materials are of a proper kind, of a good quality, and in good condition; and that other attendant circumstances—light, temperature, air, comparative silence, hours of labour, desk, seat, etc.—are satisfactory.

(c) Avoiding diffuse attention, and having the mind continuously, and just more than sufficiently, concentrated on a task.

(d) Being mindful of, and eliminating where possible, known or habitual sources of personal and common errors in task observation, memory, reasoning, and execution, and being responsive to unsuspected ones.

(e) Altering, where practicable, arrangements which lead to the making of mistakes.

(f) Recording, for personal, group, and social guidance, the various methods whereby likely mistakes may be (1) circumvented and (2) rectified in a particular task.

(g) Mental readiness to discern difficulties, exceptions, and deviations of a known order.

(h) Sufficient alertness to detect unanticipated difficulties, exceptions, and deviations.

(i) Verifying what is not quite obvious and clear.

(j) Taking nothing for granted.

(k) Shunning the habits of doubt, suspicion, and vacillation, which confuse the mind and induce inaccuracy.

(l) Displaying neatness, or clarity in purpose, in reasoning, and in execution, without which inaccuracy is frequently inevitable.

(m) Favouring a degree of conspicuousness and distinctness (or separate-ness), such as facilitates correct apprehension by the senses, the intelligence, and the feelings.

(n) Standardising the best methods for the individual, the group, or generally, ruling out thereby treacherous idiosyncrasies.

(o) Taking special precautions—by diminution of speed, of risk, etc., and by rest or by more concentrated attention—when mental or physical fatigue supervenes or when appreciable distraction occurs.

The average degree of initial accuracy attained where the above conditions are respected, may be said to be the equivalent of average accuracy, plus self-checking, and plus checking by another. In numerous tasks such accuracy may save fifty per cent. or more of labour, and in not a few investigations the saving may be incalculably great.

One example may be provided in illustration. It is said that the motto "8 hours' work, 8 hours' play, and 8 hours' sleep", offers an ideal method of dividing up the 24 hours' of a day. Now let us set out its content in the form of a time table, assuming Saturday afternoon to be a half-holiday:—

6	to	7.30	attention to the person and breakfast;
7.30	to	8	going to work;
8	to	13	morning's work;
13	to	14	dinner hour;
14	to	18	afternoon's work;
18	to	18.30	going home;
18.30	to	19.30	supper, etc.;
19.30	to	22	time not definitely occupied;
22	to	6	sleep.

Instead of 8 hours of play, we find therefore a maximum of $2\frac{1}{2}$ hours not accounted for; and if we allow for a little rest, for family and social duties, for correspondence, etc., the $2\frac{1}{2}$ hours are easily reduced to a maximum of about 1 hour for each of 4 days, and 2 hours for a 5th day, in the week. Incidentally this conclusion decisively disposes of the fear lest the universal introduction of the 8 hours' working day should create a serious leisure problem for which elaborate preparations and precautions are required. On the other hand, the younger worker may find 7 hours' sleep sufficient, in which case the leisure time may be increased by a full hour for all working days, while older men engaged on heavy work may sleep 9 hours and have left no leisure at all for the greater part of the week.

§ 125. (f) *Minuteness*.—Observation should be minute, and not only what is palpable to the ordinary observer should be chronicled. Minute examination, ever increasing in delicacy, as the history of the sciences illustrates, alone ensures that the most important facts and factors are not mistaken or inadvertently overlooked. Compare, for instance, the popular contention that thought is instantaneous, with the reaction times in psychology; or the well-known amorphous appearance of snow-flakes, with their beautiful geometrical structure when microscopically examined; or consider the delicacy of observation which revealed the satellites of Mars or the many hundreds of asteroids, or, more recently, the correctness of Einstein's theory in regard to the influence of gravitation on light rays; or ponder the fact that by suitable instruments it has been shown that each plant produces an abundant quantity of heat in respiration; or note the perfection of observation which teaches that plants seemingly devoid of chlorophyll have the green hidden by some other colour; or that some plants obtain nitrogen from the air with the help of certain bacteria; or imagine the action of the radium emanation in the atmosphere for ever causing infinitesimal amounts of nitrogen to combine with the oxygen of the air; or think of the method whereby M. and Mme. Curie obtained from pitch-blende ore a crystalline salt 1,800,000 times more active than Becquerel's uranium; or weigh the almost infinite patience exhibited by Mendelian and other experimenters; or think of the exceedingly minute analysis of bodily movements by experts in scientific industry. Or consider "letting roots grow along polished marble plates. After some weeks the marble surface clearly demonstrates the dissolving effect of growing roots and root-hairs. Delicate traces are everywhere etched in the marble surface, where roots have come into close contact with the plate." (Frederick Czapek, *Chemical Phenomena in Life*, 1911, p. 51.) Or note that "minute traces of iron salts, scarcely to be ascertained by chemical analysis, possess the power of greatly accelerating growth and

respiration.” (*Ibid.*, p. 125.) Or note how minute observation revealed that without the presence of infinitesimal portions of several classes of as yet unidentified vitamins, an otherwise perfect diet, consisting of pure proteins, carbohydrates, fats, and mineral salts, fails to sustain health and life, and that an addition to such a diet of 2 cc. of milk daily, sufficed to restore the balance; or remember the shock the layman felt when he heard (1894) that argon, a constituent of the air far from insignificant in quantity, had escaped the notice of earlier chemists, and his gratification at learning that helium, neon, krypton, and xenon, which were found to exist in the atmosphere, are present there in the proportion of one part in 245,300, 80,800, 20,000,000, and 170,000,000 parts by volume respectively.

We offer here two detailed instances where minuteness of observation is strikingly evidenced:—

Edwin S. Goodrich, in the *Evolution of Living Organisms*, 1912, thus describes the process of indirect cell division or karyokinesis: “The chromatin gathers together into a coiled thread, the linin network becomes disposed as a system of fibres radiating through the cytoplasm from two minute bodies, the centrosomes. Between these centrosomes the fibres join across, forming a spindle. The centrosomes can be seen to originate from the nucleus or its neighbourhood, as a single body which divides, the two halves moving to the opposite sides of the nucleus. The chromatic thread now breaks up into a definite number of separate pieces, the chromosomes, which arrange themselves in a circle round the equator of the spindle. Each chromosome now divides into two halves which travel to the opposite ends of the spindle. There they join together to form a thread; the thread breaks up into granules; the system of fibres disappears; and thus a new nucleus is reconstituted, similar to the resting nucleus of the original cell. A division of the cell-body then yields two nucleated cells. As a rule the centrosome persists to give rise to that of the next division. Now it is important to notice the continuity of substance during this process of division. Cytoplasm, linin, centrosome, and chromatin are all parcelled out to the two daughter cells; above all, each daughter nucleus receives the same number of chromosomes, and apparently exactly the same amount of chromatin.” (P. 22.)

The nature of the “internal secretions” produced by certain diminutive glands, regarded until recently as of no importance, has provided one of the most fascinating chapters in physiology. “The chemical substances contained in the internal secretions have been named hormones, or excitants, by Bayliss and Starling. In certain cases the chemists have been able to isolate these hormones, and in one case the chemical constitution is known and the substance has been manufactured artificially in the laboratory. In other cases, and these the majority, they are as yet only known by their definite stimulating action. Quite recently it has been shown that bodies similar in nature to the hormones must be present in our daily diet, or certain typical nutritional diseases are produced. These hormones are not foods in the sense of being necessary to provide energy by their combustion; they are only required in minute amounts as excitants, and in their absence certain very specific effects giving the clinical symptoms of well-known diseases appear. In a liberal and mixed diet all the necessary hormones required from outside are contained. But, when the diet is very restricted, such as the rice diet used by the Indian coolie, unless the thin brownish layer surrounding the inner white part of the rice be eaten in the daily diet, a disease with marked nervous lesions appears, called beri-beri. This disease long puzzled medical scientists, but it is now clearly shown to be caused by the absence from the diet

of an excitant contained in the outer layer of the rice. Addition of this cleaned-off material in small amounts prevents, or relieves, the disease. A similar condition can be produced in pigeons or fowls fed experimentally on polished rice (as the European product with the outer layer removed is called), and can be relieved immediately by small amounts of extracts of the rice polishings. Infantile scurvy is an example of an infantile disease of our own country produced by restricted diet in a similar manner. As Barlow first showed, it may rapidly be cured by treatment with fresh vegetables, such as the portion of potato lying below the rind, or fresh fruit of different kinds. There is little doubt that rickets and ship's scurvy, which are now being investigated, will prove diseases of a similar kind.

"These are examples of external hormones from outside the body required in the daily food, but the body cells within require to manufacture internal hormones, to establish important correlating functions. If the nervous system be compared to the telephonic or telegraphic system, then these internal hormones might represent the postal system of the body by which one part is kept in touch with another. The chemical intercommunication of the hormones is slower than that of the nervous system, but more detailed and complete.

"There exist in the body a number of glands with no external secretions or obvious uses which were a great mystery to the earlier anatomists and physiologists, who called them 'bodies' or 'capsules' and left the matter at that. The chief of these are called the suprarenals, the thyroids, the para-thyroids, and the pituitary. It is now known that these are active secreting glands, and in spite of their small size, and obscurity of function, are absolutely essential to the life of the animal. Their removal invariably causes death in a few days' to a few months' time, and any marked disturbance of their function in the direction either of excess or defect produces profound disease, often of a fatal character." (Benjamin Moore, *The Origin and Nature of Life*, pp. 232-235.)

More marvellous still is the action on the processes of life of the until recently unsuspected enzymes. "Most, perhaps all, of the processes of metabolism, take place with the help of special proteins, known as ferments or enzymes, which have the property of facilitating and hastening chemical actions. Just as a small trace of platinum black will cause an indefinitely large amount of hydrogen peroxide (H_2O_2) to decompose into oxygen and water, so a small quantity of ferment will cause an indefinitely large amount of carbohydrate, fat, or protein, to break up into simpler substances. Such ferments, which are not themselves affected, and which are not involved in the end products of the actions they facilitate, are called catalytic, and play a most important part in the mechanism of life." (Edwin S. Goodrich, *op.cit.*, pp. 12-13.)¹

§ 126. (g) *Wide, Varied, and Discriminating Observation.*—We should not only inspect an appreciable number of instances, but we should take heed that we diligently search for variations and for circumstances which contradict partly or wholly the hypothesis which we are endeavouring to substantiate. For example, "gun cotton can usually be burned in the open air without exploding. Yet, when it is exploded by detonation, its power is not much inferior to that of nitroglycerin". (Blanchard and Wade, *Foundations of Chemistry*, 1914, p. 423.) *Innumerable samples, culled from every imaginable and likely or unlikely source near and far in space and time should be scrutinised.* One might roughly say that observation should be from twenty

¹ On this subject consult James Beatty, *The Method of Enzyme Action*, 1917.

to fifty times more abundant, wide, studiously varied, and discriminating than it is at present outside first-class scientific enquiries. Luther Burbank's surprising successes in improving and transforming fruits and flowers, which have gained him the title of the wizard of California, are largely to be traced to his observations extending frequently to tens of thousands of specimens and over a long period of years.¹ Darwin was indefatigable in varying his experiments: "Wherever it was possible in his experiments, he varied the amount of a cause in order to note the proportionate variation in the amount of the effect; and where he had to depend upon observation alone, he made strenuous efforts to connect extreme instances by gradations of character." (Frank Cramer, *op.cit.*, p. 56.)

The local inter-relations between plants emphasise the need of wide, varied, and discriminating observation. The botanist offers us here a singularly felicitous picture. "The series of different kinds of plants playing 'follow my leader' into the fresh water ponds is another good illustration of the power of the unaided plants to change the nature of a given spot. Into the open water of a mere or pond, with its minute flora of microscopic algæ, push out the underground rhizomes of the Phragmites reed and the Bulrushes. They send up tall shafts with leaves and flowers, and in the autumn these die down, and the half rotting and fibrous remains are tangled together with the roots and rhizomes, and all tends to catch any further fragments or detritus that is drifting in the water. Gradually, by this means, the reeds collect a soil which tends to make the edge of the pond shallower, so that the Bog-Bean and other shallow water plants can come in and help in the work till so much soil is accumulated that the water is quite shallow, and rushes and Queen of the Meadow and King Cups grow on little marshy mounds with water all round them. These close up, and grasses and sedges and buttercups grow in between, and the land is almost firm and established enough to be called meadowland. Behind the grassy strip creeps down the forest, and the trees, keeping their distance behind the zone of grass, advance with its advancing edge till in time the opposite shores meet and the forest closes over the space once occupied by the pond. When this has happened, we see that the one community of plants, *viz.*, the woodland, has ousted the other, the community of water plants. It is not only individuals that struggle against each other, but whole communities that usurp each other's place. Here, indeed, we can hardly say that there is a struggle between the land and the water plants and those of the shallow shore, because by their natural growth and accumulation the former merely follow on where the latter have, by their own growth, rendered the place no longer suitable for themselves, but well adapted for those which need a built-up soil.

"Recently it has been recognised that there are definite laws which govern the series of communities that inhabit a region, and a trained ecologist, seeing one set of plants growing under certain conditions, can predict accurately what type of community will follow it—always supposing that there is no great physical change, such as would be caused by the sweeping away of the land by a great flood or its disturbance by a landslide.

¹ "We have long had various shades of black and crimson and white poppies, but no shade of blue. Out of 200,000 seedlings I found one showing a faintest trace of sky blue and planted the seed from it, and got next year one pretty blue one out of the many thousands, and now I have one almost pure blue." (Luther Burbank, as quoted by D. S. Jordan and M. L. Kellogg, *The Scientific Aspects of Luther Burbank's Work*, 1909, pp. 101-102.)

"When such a case as this occurs, and we have bare fresh land exposed, it is of interest to watch the way it is colonised. The general law that is followed is a series of changes, first from an entirely bare space to one with a few species scattered at fairly regular wide intervals over the surface, then by more species, the individuals growing closer together, but each still with space to develop completely. At this stage there are generally a very considerable number of species in proportion to the actual number of individuals. Then the species really adapted to the soil and the conditions begin to take a firm hold, and they grow more crowded together and oust the others, till at the end, when the vegetation for the spot is firmly established, there are great numbers of individuals which completely cover the ground, but there are comparatively few species."¹ (Marie Stopes, *Botany*, 1912, pp. 55-57.)

§ 127. (h) Exhaustive or Full Observation.—Examination should be repeated from time to time, long after a case appears established. A measure full and unmistakably running over should be applied. There need to be incessant trials and variations in modes of procedure in order to ensure that nothing material has escaped detection.

When, however, we state that observation should be exhaustive and full we mean that a liberal number of samples, derived from the most varied sources, far and wide, has been accurately and minutely examined. To ascertain, for instance, the body's sensibility to touch or temperature, something like a complete and minute examination of the surface of the body may be desirable, and it is also indispensable that the examination should be repeated in part and wholly at different times, in different places, and on sundry different bodies; but it would be madness to settle down to an interminable series of examinations. As Poincaré (*Science et méthode*, 1908, p. 8) well says: "While the man of science discovers one fact, billions upon billions take place in a cubic millimetre of his body." Consequently, we signify by exhaustive examination, inspection which ensures that we have satisfactorily examined a typical *sample* of fact, with its more important variations, and not all the facts as such.²

To furnish one example. Calculations purporting to give the minimum annual cost of healthy and decent living for a standard family of five in a certain locality and climate (allowing for different seasons) should at least comprise food; rent; wearing apparel (including repairs); lighting; fuel (for warming rooms

¹ The problems of commensality and symbiosis are of a kindred nature, and are well worth the attention of the methodologist. See on the subject J. Arthur Thomson, *The Study of Animal Life*, 1917.

² "One of the most striking things in Darwin's *Autobiography* is the relative importance . . . which he assigns, in his analysis of his own education, to the accumulation of facts and to the development of mental habits." (*Life and Letters of Charles Darwin*, vol. 1, pp. 51-52.) Darwin "always wished to learn as much as possible from an experiment, so that he did not confine himself to observing the single point to which the experiment was directed, and his power of seeing a number of things was wonderful." (Frank Cramer, *op. cit.*, pp. 29-30.)

and bath, cooking, etc.) and firewood; rates and taxes; trade union, political, church, and charitable contributions; full insurance and provision against illness, industrial and other accidents, invalidity, unemployment, strikes, lock-outs, child birth, old age, death (most especially of breadwinner), fire, flood, and burglary; household medicines; occasional days lost; regular and irregular fares (bicycle) and papers; smoking and drinking; stationery, other writing adjuncts, and postage; home shaving and barber; teeth, eye, ear, nose, and throat specialists; soap, soda, and other materials for cleansing, toilet, mending, and boot polishing; matches; some laundry out; one person's aid one day weekly; recreation (including club subscriptions, cinema, theatre, music hall, concert, and statutory holidays and vacations); buying, repairing, and replacing of furniture, ornaments, linen, crockery, glass, eating implements (forks, knives, and spoons), kitchen utensils, fireplace accessories, and other household articles, as well as pocket articles (purse, penknife, pencil, fountain pen, diary, note case, watch, spectacles, toothpick, nail cleaner, mirror, comb) and repairs of household and personal articles generally; moving; children's education, toys, and sweetmeats; adult education (including also books and music); cat or dog; hobbies and pets; birthday, Christmas, marriage, and other festivals and presents; flowers; visiting and visitors; a certain wages percentage of savings; a minimum for extra needs and luxuries; pocket expenses; and miscellaneous.¹

§ 128. (i) *Prolonged and Continuous Observation, and taking note of Proportion.*—Certain pills may exercise an immediate desirable effect on the human system, but yet tend to aggravate certain indispositions; physical exercise may, on the other hand, at the commencement appear to prostrate the body, while gradually steeling it; potatoes, again, may contain a very small proportion of the anti-scorbutic factor, but the considerable quantity ordinarily eaten, compensates for this; and a certain treatment or neglect may only have visible consequences weeks or months afterwards or at certain stages of life. Similarly, the likelihood of the incessant forming and unforming of habits needs to enter into all calculations relating to character and conduct. For these varied reasons distant effects should not be ignored. The prohibition of monastic orders in France, for instance, created perplexing problems in some of the countries to which the orders migrated, and the establishment of a Bolshevik government in Russia engendered an almost universal appetite and horror for Soviet rule in the working and employing classes respectively. There is also the profoundly important problem of desired, but still unexperienced, pleasures which fascinate, and are apparently

¹ For a minimum quantity budget, see Royal Meeker, *Monthly Labor Review*, Washington, June, 1920, pp. 1-18.

far more alluring than those actually experienced. Here the intrinsic drabness of all pleasures when once experienced is forgotten, with the disastrous consequence that legions of men and women are for ever craving and remain for ever unsatisfied. They appear to be unaware that only a healthy, joyous temperament is apt to find pleasures everywhere and experiences comparatively unalloyed and unebbing happiness. Therefore only when we have ascertained the law of a fact are we safe, and hence in the absence of appropriate knowledge we must be eternally vigilant, and not rest satisfied with immediate or partial results or impressions.

Quantity may also issue in an appreciable or even crucial difference. One excellent poem or speech no more makes a great poet or great orator than one swallow makes a summer; whether a handful or a million people are interested in a political question, creates a vital distinction; infinitesimal objects are difficult to detect; and the impossibility of collecting appreciable quantities, as of radium, restricts the sphere of experimentation. Thus, again, by selecting a particular sun-spot for observation and watching it, we discover that it passes from the eastern extremity of the disc to its western extremity in about twelve days, disappears for a period of the same length, then reappears, demonstrating that the sun rotates round its axis in approximately twelve days. The destructive action of the sea on its shores, of the river on its channel, and of the glacier on its bed, are further apposite illustrations of cumulative effects which require prolonged observation. Already Lucretius noted this aspect of nature: "After the revolution of many of the sun's years a ring on the finger is thinned on the under-side by wearing, the dripping from the eaves hollows a stone, the bent ploughshare of iron imperceptibly decreases in the fields, and we behold the stone-paved streets worn down by the feet of the multitude; the brass statues too at the gates show their right hands to be wasted by the touch of the numerous passers-by who greet them." (*On the Nature of Things*, Book 1.)

§ 129. (j) *Quantitative Observation*.—At least the carefully calculated average number, size, form, parts, texture, weight, prevalence, distribution, frequency, periodicity, of the object, process, or force should be supplied. (See Modal Aspects in table of Primary Categories.) Statements concerning objects should assume as nearly as possible mathematical, or at least definite, form, and exact enumeration, measurement, computation, and statistical statement, should be resorted to where practicable. Until the quantitative stage has been reached, we are properly outside the domain of science, and where this aspect is not highly developed, we can scarcely speak of a highly developed science. Words, such as often, far, much, large, fine, should be used sparingly on account of their indefiniteness.

Quantitative accuracy should be naturally proportionate to the needs of the investigation. Calculable relations, of the kind enumerated in our table of Primary Categories, need special attention.

§ 130. (*k*) *Instruments*.—Observation should be, wherever possible, instrumental. Dynamometers, ergographs, telescopes, spectroscopes, transparent and graded glass vessels, scales, diagrams, etc., and mathematical methods and formulæ should be employed. Instruments should be adapted, or new instruments invented, to suit novel requirements. The unassisted senses have wrested little from nature: they are altogether too gross and clumsy for this purpose. The acquired capacity of devising fresh and effective instruments constitutes, in some sciences, an integral portion of the outfit of the man of science, though enterprising firms of instrument makers materially second his efforts. While the naked eye can detect only about 3000 stars, instruments acquaint us with a 100,000,000, and while the reason wonders what the ocean depths harbour, the deep-sea dredge lays their marvels at our feet.

§ 131. (*l*) *Experiment*.—Observation should, of course, assume the form of experiment when circumstances are propitious. A scrupulously arranged and conducted experiment, for instance as to the solubility of food-stuffs with and without the admixture of certain glandular juices, singles out constituents and factors with the greatest assurance, but only when Conclusions 5 and 20 are complied with. Consider the problem of the protective value of colouring: "An Italian naturalist, Cesnola, tethered twenty green mantis among green herbage and twenty brown mantis among withered herbage; they were all alive seventeen days afterwards. He then tethered brown mantis in a green environment, and green in brown grass, and found that thirty-five out of forty-five were devoured within seventeen days. Professor Poulten . . . fastened 600 pupæ on leaves, fences, etc., and found that the mortality of the more conspicuous was ninety-two per cent. Professor Davenport found that, of 300 chickens in a field, twenty-four were quickly killed by crows, and that only one of the twenty-four was of the less conspicuous spotted variety." (Joseph McCabe, *The Principles of Evolution*, 1913, p.117.) Or examine a very simple problem. Walking in a certain direction at the rate of $3\frac{1}{2}$ miles per hour, I experience no wind; returning at the same rate in the opposite direction, I calculate the velocity of the wind to be apparently 7 miles per hour. Standing still, however, I simplify the conditions to the utmost, and am enabled to decide whether there is a wind blowing and, if so, what is its direction and velocity.

Experiments are sadly needed to solve some of the problems of heredity and instinct. Thus, as already adverted to, various specimens of each of the domestic and of some other animals

should be completely separated from their kind from the time of birth to full maturity, in order to resolve what is owing to contact with others of their species, and what is not. This may be afterwards varied by rearing members of one species with members of another species, and by attempts at changing the environment in diverse ways for the purpose of ascertaining the adaptability of a species. The same class of experiment might be resorted to for the purpose of ascertaining how far the characteristics of the members of one race, nation, class, or family, are due to heredity or environment. Here, of course, where the experiment is restricted to the human species, it needs to be understood that the child should be unaware that it is adopted, and also that the foster parents should treat the child as their own. In the case of man, the problem may be also elucidated by indirect experiments, *e.g.*, by studying the adaptability to varied social conditions of adopted children and the lives of individuals settled or educated abroad, and likewise by examining the re-active influences of an exotic religion, as of Islam in India, or tracing the social adaptability of the members of the same quasi-race in various countries, as in the history of the Jews, or inquiring into the effects of wholesale immigration, as in the United States, on the mental characteristics of the immigrants and their hosts. In any new sphere simple observation, with and without instruments, should precede experimental observation of a refined and quantitative nature, and the value of the latter is comparatively small where, as in the organic and cultural sciences, the issues are either complicated or still in an inchoate state. Experiment is to instrumental observation what the latter is to unaided observation. In varying an experiment of any kind, more especially Conclusions 27 and 28 should be applied. Finally, it should be remembered that truly scientific experiments are rigidly quantitative and strictly segregate individual facts and factors.

§ 132. (m) Similarities.—Observations should not slur over any similarities, however different the accompanying circumstances and however unsuggestive at first the resemblances seem. The discovery of the identity of the electric spark and of the lightning is a case in point.

Of course, all rational observation consists in grouping objects according to their similarities; but for the very purpose of disclosing resemblances we needs must, to begin with, strive also to ascertain all the existing variations relative to our enquiry.¹

¹ Darwin rightly expatiates on the importance of homologies: "What can be more curious than that the hand of a man, formed for grasping, that of a mole for digging, the leg of the horse, the paddle of the porpoise, and the wing of the bat, should all be constructed on the same pattern, and should include similar bones, in the same relative positions? How curious it is, to give a subordinate though striking instance, that the hind-feet of

§ 133. (n) *Relevant Observation*.—To commence seriously the work of observation in any particular instance without making preliminary observations, would render observation a very circumlocutory proceeding. In examining an object, to be obliged to valueate the influence of the stars, the light, the temperature, the atmosphere, the dust, the surrounding objects, the noises in the neighbourhood, the distant past, and the thousand other latencies, would be disheartening. Yet the greatest circumspection is requisite that no relevant facts are passed over or classed as irrelevant, as, for instance, the direct influence of sunspots on magnetic storms, of the sun and moon on the tides, the sun on the leaves of plants, the times of day and night on leaves and flowers, and the time of year on growth. The attempt to reach the absolute zero of temperature and to produce the highest possible degrees of heat is, for example, of far-reaching importance, but such problems should be treated separately, and not in connection with every enquiry.

§ 134. (o) *Rational Observation*.—Not only should the irrelevant environment be left unexamined, but sundry features, as the precise configuration of an ordinary object, and hosts of other aspects, should be generally disregarded. A danger exists here that we shall consider as irrational what is rational; practice, however, will reduce the danger to a minimum. To endeavour to provide the exact configuration of every leaf, or the exact drawing of the veins in each leaf, would be irrational, and yet even of these some very definite conception, even of a quantitative and dynamic character, should be supplied.¹ For similar reasons, we only study objects so far as they relate to a particular investigation. (See § 170.)

§ 135. (p) *Rapidity and Resourcefulness*.—Observation should be rapid and the observer resourceful. Action should not be paralysed by inaccuracy, by blundering awkwardness, by persistent speculation, by overcautiousness or vacillation, or by lack of method or resourcefulness. The immediate task needs to be clearly conceived and energetically executed, without any hitch or superfluous labour.

He who is intelligent, has an unmistakable desire to effect his purpose expeditiously, and, if trained and practised, will

the kangaroo, which are so well fitted for bounding over the open plains,—those of the climbing, leaf-eating koala, equally well fitted for grasping the branches of trees,—those of the ground-dwelling, insect or root eating, bandicots,—and those of some other Australian marsupials, should all be constructed on the same extraordinary type, namely with the bones of the second and third digits extremely slender and enveloped within the same skin, so that they appear like a single toe furnished with two claws. Notwithstanding this similarity of pattern, it is obvious that the hind-feet of these several animals are used for as widely different purposes as it is possible to conceive.” (*Origin of Species*, Chapter 14, Section “Morphology.”)

¹ Josiah Royce, in *Encyclopædia of Philosophy*, vol. 1, 1913, deals with the nature of a “fair sample”.

act in conformity with the principles developed at length in Conclusion 10, to which we accordingly refer the reader.

Rapidity is a most desirable virtue. Consider, as an example, the late Lord Avebury. He was during his life-time president of some fifteen learned societies; he wrote over twenty volumes on almost as many topics, a number of them of marked scientific value; he contributed over a hundred memoirs to the Transactions of the Royal Society; he was a well-known constructive politician and a supporter of many causes; and at the same time he acted as one of the heads of a great banking firm and was the chairman of the London Bankers and the president of the Central Association of English Bankers. Darwin wrote a dozen large works of the first order, though he was far from robust in health. John Stuart Mill, whilst busy as an official of the East India Company all his life, published a quantity of classic treatises. Aristotle's intellectual output was no less remarkable for its variety than for its quality. Consequently, there is good reason for surmising that a colossal preventable wastage of energy is the rule with most scholars. Those who are quick, no doubt compass what they desire with the expenditure of a minimum of energy. Lord Avebury, whom the author had the privilege of knowing, certainly appeared neither feverishly preoccupied nor engaged in a breathless race. On the contrary, he was one of the most leisurely scholars he has been acquainted with.

He who has really a rooted desire to be swift will also tend to be resourceful. Accordingly we shall state some of the rules conducing to resourcefulness:

(a) Take for granted that most minor difficulties are easily resolved; that most ordinary difficulties are really minor difficulties; and that ready adaptability is the chief secret of resourcefulness.

(b) Be well acquainted with your subject: this will enable you to meet many difficulties, since most present contingencies contain no novel element.

(c) Hold fast, adapt, and generalise to the furthest degree for future use, any ingenious method or idea, positive or critical, suggested by accident or otherwise.

(d) Heed the manifold lessons of experience: this will frequently help you to remember solved difficulties identical or similar to the one which perplexes you.

(e) Be guided also by the lessons taught by the experience of others, especially of those who are resourceful.

(f) To meet a particular case freely exploit (1) every cranny of the past for relevant recollections and (2) near and distant analogies relating to past and present.

(g) Ascertain the precise problem and find any method which will resolve it. Example: Should the birds keep you awake in the early morning, or the traffic at night, deal with the *precise* problem—loud sounds,¹ to which one simple solution might be—cotton wool in the ears.

¹ In connection with the nightly rest, this is a social problem of the first magnitude in towns, to which it would be highly desirable to find a simple solution. Neither closed windows nor living in suburbs offers the ideal

(h) Grow accustomed to meet *any* difficulty by *any* convenient and lawful means.

(i) If one condition—*e.g.*, a particular time, place, degree, size, number, environment, connection, etc.,—is not satisfactory, probably another will be. (Example: 10 o'clock or 12 o'clock will probably do for an appointment as well as 11 o'clock.)

(j) If one means or object is not satisfactory, probably another will be.

(k) Define the problem in the largest term, *e.g.*, something to resolve or to fasten, some habit or receptacle, something to be made sure of or secure, some attractive or heavy object—and then seek its solution. (Example: if a certain receptacle is inaccessible, another, never mind its form, size, or ordinary use, may be at our disposal.)

(l) When you cannot obtain an object one way, try another and other ways, and endeavour also to remember other, and others', ways.

(m) Assume that virtually everything can be accomplished, and that it can be accomplished in more ways than one, and better.

(n) Even if one way will effect your purpose, essay other ways for practice and delight.

(o) Undergo a course of training in resourcefulness, and periodically experiment systematically and on an extensive scale by yourself.

§ 136. (q) *Graded, Comprehensive, Important, Full, Rational and Relevant, Original, Automatically Initiated, and Methodically Developed Observation.*—Conclusion 25 deals indirectly, but amply, with these aspects of observation, so far as they are not already touched on in this Conclusion. We therefore refrain from illustrating the latter in this place.

Lotze has many excellent remarks concerning observation; but he scarcely meets the points mentioned in the above Conclusion. As to wide observation, for instance, he only states: "The individual subjects from the observation of which we start must be very numerous." (*Logic*, vol. 2, p. 33.) Bain vaguely refers to "wide comparison of particulars". (*Logic*, vol. 2, p. 403.) It is poor consolation when he adds: "The precautions common to all kinds of observation, in regard to accuracy and evidence, would be worthy of being recited, provided there could be given a sufficiency of illustrative instances to make the desired impression." (*Ibid.*, p. 414.) If, as Jevons (*Principles of Science*, p. 399) says, "all knowledge proceeds originally from experience", then no effort can be too sustained to make sure that the raw material of thought shall be of an irreproachable character. Whewell also expresses himself prophetically: "Methods of observation and of induction might of themselves form an abundant subject for a treatise, and hereafter will probably do so, in the hands of future writers." (*Novum Organum Renovatum*, p. 144.) Mill asserts: "It would be possible to point out what qualities of mind, and modes of mental culture fit a person for being a good observer: that, however, is a question not of Logic, but of the Theory of Education, in the most enlarged sense of the term. There is not properly an Art of Observing. There may be rules for observing. But these, like rules for inventing, are properly instructions for the preparation of one's own mind; for putting it into the state in which it will be most fitted to observe, or most likely to invent. They are, therefore, essentially rules of self-education, which is a different thing from Logic. They do not teach how to do the thing, but how to make ourselves capable of doing it. They

answer required. Direct protection of the ears from aggressive sounds, it appears, should rather be aimed at. (The author has empirically, and somewhat crudely, solved the problem for himself by covering both his ears with his bed pillow in going to sleep and in the early morning when disturbed.)

are an art of strengthening the limbs, not an art of using them". (*Logic*, bk. 3, ch. 7, § 1.) Thomas Fowler (*Logic, Deductive and Inductive*, vol. 2, pp. 45-50) furnishes four rules pertaining to observation and experiment.

The following instances form extreme illustrations of theories based on inadequate observation: "It appears that, whenever oats sown at the usual time are kept cropped down during summer and autumn, and allowed to remain over the winter, a thin crop of rye is the harvest presented at the close of the ensuing summer. This experiment has been tried repeatedly, with but one result: invariably the *Secale cereale* is the crop reaped where the *Avena sativa*, a recognised different genus, was sown." (Robert Chambers, *Vestiges of the Natural History of Creation*, ed. 1887, pp. 166-167.) And a qualified scientific populariser, Mr. Edward Clodd, in his work, *The Story of Creation*, tells an equally dubious tale, since the exploits of St. Bernard dogs appear to be legendary in character: "An interesting illustration of this was supplied by a St. Bernard dog belonging to a relative. The dog was born in London and taken into the country when a puppy. After a few months a sharp fall of snow happened, and 'Ju', who had never seen snow before, was frantic to get outdoors. When she was set free, she rolled in the snow, bit it, and dug it up with her claws as if rescuing some buried traveller. The same excitement was shown whenever snow fell." (P. 114.) A more interesting case even is the alleged proof of the non-existence of spontaneous generation by boiling the water which might presumably contain germs, and the counter claim that such boiling destroys the conditions necessary for spontaneous generation. The difficulty of correct observation is also well exemplified in the modern instance where a supposed organic form, christened the *Eozoön canadense*, has been shown to be an inorganic substance, or in the more recent circumstance where doubt has been cast on the human origin of certain eoliths.

We have intentionally omitted a series of points concerning observation, which, we deemed, require special treatment. We shall now proceed to consider these.

CONCLUSION 17.

Need of Critically Examining the Reality of Alleged Divisions.¹

§ 137. (A) *Complex Facts regarded as Simple*.—In commencing an investigation we should not assume that we are dealing with isolated entities, without first ascertaining whether this is so in fact. Under a close scrutiny the air proved to consist virtually of two elements and to contain a number of others; the nitrogen of the air was shown, further, to have associated with it argon, and, in close connection with argon, Ramsay and others found three more elements—neon, krypton, and xenon—these, with helium, constituting the rare gases of the atmosphere; the seemingly homogeneous air has been divided into a lower Troposphere, where the temperature of the air varies always both horizontally and vertically, and an upper Stratosphere, where it only varies horizontally. Common salt, on more careful examination, proved to be a compound; oxygen,

¹ "No one can divide things truly who has not a full knowledge of their nature." (Bacon, *The Alphabet of Nature*.)

carbon, phosphorus, and sulphur were shown to have allotropic forms, and the same fact, expressed as isomerism, was traced in many compounds; radium was found to decompose into a variety of elements, including helium; the consumed taper and the evaporated water were shown to persist in an altered form; for want of a critical attitude, the ancients spoke of earth, water, fire, and air as the four elements, and only dimly distinguished as a rule between copper, bronze, and brass, whilst until two centuries ago, all gases were regarded as the elementary substance air, modified by impurities; the blood proved to be a treasure house of varied substances; the process of digestion, instead of being carried on, as common sense supposed, in the stomach alone and by some simple method, proves to be an exceedingly lengthy and complicated process, commencing with mastication and salivation, and continuing some time after the modified food has left the stomach; and severe epidemics were traced to certain animal parasites rather than to the animals which carried the parasites. Death is regarded as a sudden cessation of life, when the heart may be made to renew its beating in certain conditions thirty hours afterwards, when the beard and the nails continue growing, and when the protoplasm in diverse parts is unaffected for some time afterwards. The old atomic theory suggested the existence of a simple atom, whilst the new atomic theory resolves the atom into a complex system. The average townsman cannot tell from the notes in the wood whether he hears many birds or one; martin and swallow, or rook and crow, represent for him a single species, and he fails to distinguish closely allied kinds of flowers and trees; all grasses are grass to him. In the mental realm, on this same account, the phrenologists neglected the simple and general principles of mind, and most students have been led to believe that the senses offer their own explanation. This is true also of many popular terms, such as beauty, imagination, skill, genius, character, goodness, truth, love, etc. Piece-work seems fair, until we learn that increased output may lead to a proportionate decrease of price per piece; gratuities may appear defensible, until we learn that a waiter may actually have to pay for his post; obedience loses its virtue when it induces tyranny in the master; and wages lose their simplicity, when the cost of living is taken into account. Or to cite an example from anthropology, one of many similar ones with which Prof. Franz Boas deals: "One of the striking forms of social organisation which occurs in many religions wide apart is what we called 'totemism'—a form of society in which certain social groups consider themselves as related in a supernatural way to a certain species of animals or to a certain class of objects. I believe this is the generally accepted definition of 'totemism'; but I am convinced that in this form the phenomenon is not a single psychological problem, but em-

braces the most diverse psychological elements. In some cases people believe themselves to be descendants of the animal whose protection they enjoy. In other cases an animal or some other object may have appeared to an ancestor of the social group, and may have promised to become his protector, and the friendship between the animal and the ancestor was then transmitted to his descendants. In still other cases a certain social group in a tribe may have the power of securing by magical means and with great ease a certain kind of animal or of increasing its numbers, and the supernatural relation may be established in this way." (*The Mind of Primitive Man*, 1911, pp. 190–191.) Lastly, it is very general, for psychological reasons, to favour a tripartite classification of facts, when the number should be far higher as a rule. At all times, in short, men have regarded the complex as simple and that which is divisible as indivisible, and have been seriously deceived on this account.

In the fiftieth aphorism of the first book of his *Novum Organum* Bacon places his finger on the weakest spot in all non-scientific speculation. He acutely remarks that "speculation commonly ceases where sight ceases; inasmuch that of things invisible there is little or no observation". Almost the entire history of science is an exemplification of this aphorism, for *that which strikes the unassisted senses is most generally of small consequence in leading to scientific advance*. We have only to think of chemical elements and their modes of combining, of the constitution of the air, of heat, light, and electricity, of the formation of the strata of the earth, of protoplasm, and of the cell structure of all that lives, of the assimilation of food by plants and animals, of the specio-historical character of man's mental outfit, of the bacterial origin of many diseases, to appreciate the fact that the subtlety of nature escapes ordinary perception, and that non-scientific or common speculation, must needs be barren and erroneous since it is necessarily based on unaided perception which brings together what is separate and separates what is united.¹ Darwin rightly watched for exceptions, because these alone, generally speaking, point to primary factors, whereas what is present to vision as such is

¹ The recent investigations relating to radio-activity illustrate the above contention: "The quantity of radium present in pitch-blende is extremely small, many tons of the material yielding, after long and tedious work, only a small fraction of a gramme of an impure salt of radium." (Whetham, *The Recent Development of Physical Science*, 1904, p. 202.) Likewise, "Sir William Roberts-Austen has shown that gold, if placed in intimate contact with lead, will diffuse at ordinary temperatures to such an extent that, after the lapse of some years, it can be detected in the lead by chemical analysis at distances of a millimetre or more from the surface of contact." (*Ibid.*, p. 247.) Also, many metals occlude or absorb considerable quantities of hydrogen and certain quantities of oxygen. (A. H. Hiorns, *Principles of Metallurgy*, 1914, pp. 10–11.)

habitually a highly complex compound already tainted with an interpretation which is convenient only for practical purposes. As Jevons (*Principles of Science*, p. 506) contends: "A phenomenon which seems simple is, in all probability, really complex, and unless the mind is actively engaged in looking for particular details, it is likely that the critical circumstances will be passed over." And in another place he asserts that "the progress of science depends on the study of exceptional phenomena". (*Ibid.*, p. 644.) Sir John Herschel spoke without hesitancy when adverting to the attitude of the scientific thinker: "He will have his eyes as it were opened, that they may be struck at once with any occurrence which, according to received theories, ought not to happen, for these", he significantly adds, "are the facts which serve as clues to new discoveries." (*Discourse*, [127.]) Without alertly watching for exceptions to supposed laws, we are not likely to discover the primary constituents and factors.

§ 138. (*B*) *Simple Facts regarded as Complex*.—We should also specifically guard against the opposite misapprehension of surmising complexity where there is simplicity. This is too evident to need labouring. The Universe is a multiverse to the mass of mankind. At one time the hundreds of thousands of species were accounted for by special creation; the tower of Babel was evolved to explain the diversity of tongues; and earth, moon, sun, and planets were regarded as independent entities. The layman sees innumerable kinds of rock where the geologist discerns only sandstone, granite, and limestone; he counts many orders of clouds where the meteorologist distinguishes only three—cirrus, cumulus, and stratus; he opines numerous ways of communicating heat where the physicist speaks of conduction, convection, and radiation; he conceives sunstroke as only due to heat, when chemical and other factors are involved; he assumes diamond, graphite, lamp black, and pure charcoal to be essentially different, when they are each forms of carbon; and he sees bodies, where the chemist recognises compound molecules and the biologist compound cells. So, again, the older chemists rigidly separated inorganic from organic chemistry, the latter being dependent, according to them, on a vital principle; and now compounds are found to be related to higher compounds as elements or radicles. The polygenetic theory of races had many defenders, and in social matters special explanations for individual occurrences, such as individual idleness or stupidity, are proffered where general explanations—economic chaos or an unsatisfactory educational system, for instance—are rightly in place. If we analyse, again, an emotion, we shall probably note that the definition properly comprises a mental excitement aroused directly by some definite disturbing object or idea, accompanied by a concomitant physical excitement, and excludes a host of facts usually included through inadequate analysis—such as natural inclination, sentiment, temperament,

and moods.¹ An analysis of pleasure-pain furnishes analogous conclusions.

§ 139. (C) *Environment Ignored*.—Another aspect of our problem needs also to be considered here. If one substance, as shown in (A), may be so intimately joined to another that the two appear as one unless painstakingly examined, another substance may depend on some factor in its immediate environment—*e.g.*, many diseases are traceable to parasites—and we may gloss over this factor, and seek to explain the behaviour of the substance without regard to its surroundings. Many illustrations of this oversight may be found in the realm of specio-psychics. We explain French style, Italian art, German scholarship, and English colonising skill by certain alleged indwelling powers in the individuals belonging to these four peoples, without fully inquiring whether perhaps all four qualities are not produced by the respective environment—geographical, intellectual, moral, and economic. We read of a Shakespeare and a Goethe, and we endeavour by their means to explain their environment, without asking ourselves how far the contrary may hold true, and they be best explained by their surroundings. We are dissatisfied with those around us, and we decide that supermen are needed, when what is required is perhaps a super-civilisation. We see men struggling successfully against their environment, and we insist that man is wholly free to do as he listeth; or we perceive men gravely deteriorated by their environment, and we bring in a plea of “not guilty”, and relieve the individual of every effort, when the responsibility should be perhaps divided between individual and environment. We observe Negroes in Africa dancing round fetishes, and we forthwith consider them as more beasts than men, when with Western nurture these Negroes might have graduated in a European university, and some of them even have occupied university chairs. We notice women confined to their homes and interested in balls and dresses chiefly, and we unhesitatingly decide that woman’s place is the home, when, perhaps, under reversed circumstances, men and women might exchange places. We encounter two men who differ widely in intellectual leanings, and we declare that the difference lies primordially in their innate intellectual aptitudes, when education, opportunity, comfort, and many other causes, may enter as more or less decisive factors. The enormous powers of home and school education, of social traditions and institutions, of position in the social scale, are frequently not even suspected, let alone seriously weighed, whereas no enquiry relating to man should consider them otherwise than as momentous. The environment as a primary factor is thus habitually overlooked.

¹ See G. Spiller, “The Problem of the Emotions”, in *American Journal of Psychology*, vol. XV.

So, also, definite factors in the environment, rather than inherent virtues, explain much that is of moment economically: "The dominant industrial position of England is due, in a large measure, to her possession of an abundance of [iron and coal]." (Banerjea, *Indian Economics*, p. 13.) Likewise, "natural water-supply is the chief factor determining the density of population and the state of civilisation in any particular part of India" (*ibid.*, p. 22), whilst "the Himalayas act as a climatic barrier in shutting out the cold winds of Central Asia and keeping within the borders of India the vapour-bearing winds of the south-west monsoon" (*ibid.*, p. 16). Furthermore, the far-reaching social effects of the gulf-stream on England, and of the great ocean currents generally, may be noted.

The apparent incapacity of the African Negro to civilise himself may be said to be due equally to traceable environmental causes. This will be readily seen when we examine the Western method of introducing civilisation into Africa. It is not that the European settles on Africa's shores, and by sheer superior brain force evolves a high civilisation. It is rather that European colonising Governments spend in Africa millions of pounds on railways, roads, rivers, and ports; that they apply modern hygiene, sanitation, and knowledge of germ pests; that they experimentally and otherwise study the crops best suited for the climate and soils, and by modern surveying methods ascertain the existing mineral treasures; that, in short, Western Governments develop African countries with the aid of great wealth, of science, and of tried administrative and commercial experience. This renders it manifest that the African, even in the most favourable circumstances, would require many generations to do what a European State, by its accumulated store of money, science, and power, could accomplish within a comparatively few years. We have not, therefore, before us a clear case of racial inferiority and superiority, but a matter of great environmental resources, on the one hand, and trifling environmental resources, on the other.

In order to eschew ignoring the temporal, spatial, and ideational environment, the following rule may be applied with advantage: "In any investigation assume only, initially, *the bare, naked fact* (e.g., that there are at this moment universities in Italy, but none in Mashonaland, or that one man is long-headed and another round-headed). As to what was or what will be, as to causes and environmental conditions, *carefully examine; assume and deduce nothing as a matter of course, and beware of disregarding or undervaluing the environment, present and past, physical, biological, and cultural.*" Two sub-rules are needed: (1) to prepare increasingly complete lists of the general and special conditions for the subject matter of all the sciences and arts. Among physicists this is well understood. The possible or actual presence of gravity, cohesion, repulsion,

strain, stress, motion, momentum, friction, vibration, light, magnetism, electricity, heat, chemical affinity, diverse kinds of rays, potential and kinetic energy, surrounding objects, moisture, floating particles and diffused gases, the atmosphere and its constituents, movement and pressure, impurities, and the need for isolation, are circumstances almost never left out of account in physical investigations. In cultural enquiries the standard should not be less exacting. Latitude, longitude, general climatic conditions, elevation and configuration of locality, soil, sub-soil, mineral wealth, proximity to other localities and countries small and large, and to plain, mountain, forest, sea, lakes, ponds, streams, or navigable or other rivers, underground water, domesticated and wild animals, cultivated and uncultivated plants, temperature, light, purity and moisture of the atmosphere, food, drinking water, fuels, sanitation and hygiene, habitations, garments, free disease germs and diseases-carrying insects and animals, size of community, language, race, and national affinities, sex, age, family life, customs, morals, religions, economic status, social position and differentiation, social and associational life, friendship, means of communication, economic conditions, resources, and development, occupations and recreations, state of land exploitation and land laws, fisheries and navigation, government and political liberties and parties, laws, militarism and navalism, local administration, history, home, school, vocational, and self-education, sciences and arts, museums and galleries, national, vocational, family, and personal ideals, love of progress, etc., etc., should all be always respected in any serious social study.¹ Furthermore, (2) where artificial experiment cannot be applied, Nature's experiment should be heeded, as revealed in history, in different countries, in apparent exceptions, and in the effects of intermixture and intercommunication.

§ 140. (D) *Influence of Time and of Position in Space and Mind.*—It is also of consequence to allow for a fourth aspect, alluded to already in the immediately preceding Sub-Conclusion. Seeing the general uniformity obtaining in nature, we confound the moment with eternity, the here with the there, and omit to notice, for instance, that

"In the Spring a fuller crimson comes upon the robin's breast;
In the Spring the wanton lapwing gets himself another crest";

whilst as for the wagtail, "he is black and white all over in summer; with white cheeks and forehead, and black chin and

¹ The American paper, *System*, published the following comprehensive list of qualities to be taken note of in industry and commerce: "business knowledge, technical knowledge, tact, reliability, perception, resource, manners, foresight, energy, memory, pertinacity, accuracy, method, self-reliance, initiative, self-assertion, discipline, persuasiveness, education, temperance, punctuality, morality". (Quoted from E. Waxweiler, *Esquisse d'une sociologie*, 1906, p. 204.) Full lists would be invaluable in every subject—e.g., the demands of labour, the claims of capital. Endless disputations, due to lack of comprehensiveness, might be thus averted.

throat; but in winter he changes and becomes grey instead of black on the back and his chin and throat become white"; and "the magpie, so wary in England, is tame in Norway, as is the hooded crow in Egypt" (Darwin). Equally, who that had seen but one dog would suspect the existing variety of dogs, or who that had seen the plants of the valleys would suspect the transformation some of them undergo when transferred to the Alpine heights above. Similarly, an ancient Teuton would not have been justified in reasoning that all men are fair, any more than his brother in the tropics who judges that all men are dark brown. Thus, again, whereas a census of school children would furnish a given percentage of fair-hairedness, that of adults would exhibit a conspicuous decrease in the percentage, and whilst one part of a country may be wholly literate or densely populated, another may be almost illiterate or sparsely inhabited. Who, once more, living in the far south would conjecture the existence of the far north, and who, living in either extreme of climate, would surmise that there are many places on earth where decided heat and decided cold alternate during the year?¹ Who, again, living in a monogamous civilisation is not surprised to hear of the prevalence in other civilisations of polygamy and polyandry and *vice versa*? The towering Patagonian in his retreat imagines that some of his fellows of no more than six feet in height are diminutive, whilst the pigmy of the gloomy African forest would be amazed to face a man who reaches five feet. It is equally a never-ending comment of new-fledged travellers that there should be

¹ "Over the British Islands the average rainfall is about 25 inches per annum; but the amount varies greatly from year to year, and also from place to place. It is greatest in the West and North-West of the country. At Seathwaite in Cumberland, reputed the wettest spot in the British Isles at which regular observations have been made over many years, the average amount is 139 inches per annum. In tropical countries, where the air can contain much larger amounts of water vapour by reason of its higher temperature, much higher figures are recorded. Cherra Poonjee in Assam has an average rainfall of 439 inches per annum, the highest known rainfall for any station at which observations have been made for many years.

"A day on which the rainfall exceeds one inch is regarded as one of heavy rain in all parts of the British Isles, though a glance through a set of rainfall tables for almost any year shows that this phenomenon may be expected to occur at least once in the course of each year at most British stations. The heaviest fall of rain ever recorded in one day in the British Isles again falls to the lot of Seathwaite, where, according to an interesting table of phenomenally heavy rainfalls given in *British Rainfall* for 1910, 8.03 inches of rain were measured in November 12, 1897. Even in our comparatively dry Eastern counties very heavy falls may occur. The same table records seven instances of falls exceeding 4 inches in 24 hours in the county of Essex.

"In tropical countries these amounts may, again, be vastly exceeded. For example, a typhoon which swept over the Philippine Islands between July 14 and 17, 1911, deposited at one station on four consecutive days 35, 29, 17 and 8 inches respectively, or a total of 89 inches in four days." (R. G. K. Lempfert, *op. cit.*, pp. 23-24.)

in any country customs other than their own. One remembers in this connection Mark Twain's genial Negro who could not comprehend why the French people did not speak English. The molecular movements of objects at rest or in the growth of animate beings remain for this reason commonly unnoticed, just as at first the isomeric aspects of compounds escape attention; we ignore the fact that a "given mass weighs slightly less, and falls to the ground a little less rapidly, in the tropics than elsewhere" (F. Soddy, *op. cit.*, p. 25), or that the requirements of children often seriously differ from those of adults, or that a remedy efficacious at one stage, or in one affection, may be useless or even detrimental at an earlier or later stage, or in another affection; and the influence of vast periods, as in the formation of mountains, rivers, or land, or in the evolution of living forms or even of chemical elements, or in the development of human institutions and human culture, demand measurement, whilst in theoretical and practical problems, the near and distant future equally require to be taken into account. "At the time of Alexander's invasion a good part of the now arid desert consisted of populous towns and prosperous villages. So also, the jungle now known as the Sunderbun, and inhabited by tigers and other wild beasts, was, a few centuries ago, the seat of a flourishing kingdom." (Banerjea, *op. cit.*, p. 8.) And time sees important changes induced by man's interposition. "The worst land can be converted into the most fertile by the application of proper manures and the adoption of a well-regulated method of agriculture. . . . Afforestation may lead to an increase in rainfall where it is at present scanty, and irrigation may be so practised as to carry water to any place where it is wanted." (*Ibid.*, p. 26.) What more wonderful substance is there in nature than water? Now it is a transparent liquid evaporating in almost any degree of temperature, saturating the atmosphere, forming steam and clouds, descending from the sky as rain, snow, sleet, and hail, appearing as sparkling dew and lacy frost, turning into solid ice, splitting the rocks because of its unique quality of expanding just anterior to solidifying, and entering largely into the composition of living forms. Sufficient has been adduced to show the need of always calculating on the possibility that objects and their environment do not possess that uniformity which they momentarily and in certain localities appear to present.

"There rolls the deep where grew the tree.

O earth, what changes hast thou seen!

There where the long street roars, hath been
The stillness of the central sea.

The hills are shadows, and they flow

From form to form, and nothing stands;

They melt like mist, the solid lands,

Like clouds they shape themselves and go."

(Tennyson, *In Memoriam*, cxxlii.)

In dealing, then, with the nature and relations of phenomena, we should suspect complexity where there appears to be simplicity, simplicity where there appears complexity, environmental influences where other influences are alleged, and we should be prepared to find that influences of time and of position in space and mind produce, as the case may be, an appreciable or a substantial difference.

CONCLUSION 18.

Need of Keeping and Consulting Records, of Improving the Memory Experimentally, of Employing the Imagination, and of utilising the Intelligence in its entirety.

§ 141. (A) KEEPING AND CONSULTING RECORDS.—As is evident from the very definition of a given impression as entailing special memory, general memory, and reasoning or inference from past to present experience,¹ it follows that in the scientific process of investigation the place of the memory cannot be left unconsidered. Furthermore, memories not only fade rapidly, but become confused. Lastly, not only does memory enter into the process of observation; but more especially does it weave itself into the whole generalising and reasoning process. We cannot recall all we have observed; and even if we have kept adequate notes, these are not as exhaustive as the original observations.

Since, then, the memory needs to be employed, we should prepare rules for its guidance: (a) we should consult records entered carefully at the time of observing, containing all we observed and nought beyond, and succinctly, systematically, and lucidly composed; (b) only such memories are to be utilised as are distinctly recollected to have been scientifically gathered; (c) these records and recollections, especially if much is to depend on them, should be verified with meticulous care; and (d), according to circumstances, these records should assume the form of specimens, rough sketches, minute drawings, coloured drawings, photographs, tables, statistics, graphs, and the like.

§ 142. (B) IMPROVING THE MEMORY.—Moreover, strenuous efforts should be made to improve the memory as such. (a) By observing accurately with the object of accurately recollecting, and then experimentally training the memory in this direction, we may hope to find our memories far more reliable than at present. (b) Similarly, by pursuing an analogous method in relation to completeness of memories, parallel results are likely to ensue. (c) Kindred methods should be employed to create an extensive store of memories, without which the task of

¹ See § 19.

investigation and elaboration proves slow and difficult. Then (d) there is the problem of training the memory in order that it should readily respond to the demands made on it. And lastly, (e) a methodological memory is of vital import for rapid methodological thinking. This last point needs to be developed. Many more or less coherent classifications exist in our day, and through experimental training it might be possible that, given certain terms, most relevant related terms should, in a methodical manner, almost instantaneously appear in consciousness. In this way, especially if the process be systematised, and if it be extended to relevant facts, ideas, conclusions, etc., the value of thought may be considerably improved. Even this, however, should not satisfy the methodologist, for we ought to aim at (f) so developing the memory by means of experiment that everything *involved* in a thought shall be readily *evolved* by the memory. That this takes place to some extent normally will not be disputed; but if it occurs at all, the conscious perfecting of the process should not meet with insurmountable obstacles. Having successfully trained the memory in this direction, methodological thinking would be, comparatively speaking, lightning-like.

In our time, because of the subjective seclusion of thought, the memory is relatively unsocial and therefore chaotic; but, once controlled by collectively devised methods, it ought to operate as smoothly and satisfactorily as high-grade machinery. It will be understood, of course, that we assume a memory well-stocked with sifted and organised facts and ideas, and assisted by a series of methodological Conclusions of the type proposed in this volume.

§ 143. (C) *SCIENTIFIC USE OF THE IMAGINATION*.¹—The memory has a further important function to fulfil in the course of scientific investigation; for not only do we require to recall the bare facts specifically examined, but it is desirable to recollect related facts which might have a bearing on the subject in question and help towards its elucidation. A well-stored and responsive memory is thus of capital importance. In seeking to explain, for instance, the alarming growth of a disease, such as appendicitis or cancer, experts have not stumbled on any explanation as the effect of studying actual cases. They, accordingly, seek for environmental influences. Is the disease especially prevalent among the poor or rich, among the educated or uneducated, among heavy or light eaters, among those who consume much or little of particular food-stuffs or beverages, among those who overwork or underwork, among civilised or primitive peoples, and so on? Hasty solutions are

¹ "Nourished by knowledge patiently won; bounded and conditioned by co-operant Reason, Imagination becomes the mightiest instrument of the physical discoverer." (John Tyndall, *Scientific Use of the Imagination, and Other Essays*, 1872, p. 6.)

easily offered; but the difficulty is to fix unmistakably on the source of the evil, which only the widest and most searching examination may be able to disclose. Cholera, plague, consumption, insanity, and certain deficiency diseases, have been in this manner more or less successfully traced to their causes, and this has invariably entailed much circumspect drawing on a copious memory, though, of course, not without detailed attention to the circumstantial facts of the disease. In the physical sciences the use of the imagination is for this reason increasingly required, since gravitation, heat, light, electricity, magnetism, radiation, chemistry, and now astronomy, begin to melt into one another and to interpret each other, and since so much is invisible owing to diminutiveness or bulkiness and demands recourse to analogy for the purpose of determining the nature and causes of objects and processes. Thus, to venture on one illustration from geology, where the factors are frequently difficult to trace and where the instructed imagination proves to be a valuable auxiliary. "It is believed that the accumulation of a sheet of ice, several thousand feet in thickness, will depress that part of the earth's crust on which it rests. On the other hand, the part of the crust which lies immediately to the south of the ice-sheet will well upwards, it is believed, in the form of a wave, giving rise to such an elevation as is occurring in Scandinavia now. Still further south, beyond the wave of elevation, there is a secondary trough or depression." (A. Keith, *The Antiquity of Man*, 1920, p. 45.) Also, once we ascertain that man is primarily a specio-psychic being, the explanation of innumerable human facts will be sought in the multitudinous cultural forces in operation, and this can only be accomplished by passing mentally in review apposite data and reconstructing situations in the imagination.

For instance, here and there sundry writers have lightly touched on the cultural nature of man; but through failing to develop the conception, they have left the subject in a rudimentary condition impotent to affect current theories. On this account it was relatively easy for Darwin, and those who followed him, to overlook the real inwardness of the cultural factor. If man possessed this, that, and the other quality, why, it was reasoned, characters resembling these could be detected scattered throughout the animal kingdom, and if culturists spoke of human progress, it was not difficult to confuse cultural with biological progress, and even to deny progress by citing exceptional or petty instances suggestive of the absence of progress. A proper use of the imagination would have quickly shown that, first, a relevant comparison could only be instituted between man and some *one* particular animal species, not between man and *all* animal species. Furthermore, by patiently analysing the wealth of human culture—as regards means of communicating feelings and thoughts to one's fellow creatures,

roads and modes of transportation, buildings and furniture, callings and variety of implements and products, domestication of animals and cultivation of plants, discovery and utilisation of raw materials and natural forces, dress and education, nutrition and care of health, trade and internationalism, morals and religion, art and science, law and government, marriage and other voluntary and territorial associations—it would have clearly revealed itself that every animal species is outdistanced by man to an almost infinite degree.

Moreover, by breaking up the notion of richness, it would have transpired that culture is distributed with extreme inequality among persons, peoples, and periods; that it has been produced by a process of progressive accumulation and improvement from the earliest times to to-day; and that virtually all mankind has co-operated to compass this. Human life is thus perceived to differ from all animal life by being almost infinitely richer, and almost infinitely more varied, progressive, unified, and perfectible. Incidentally we learn, then, that cultural variations are primarily due to cultural causes; that a survey of human history as a whole bears witness to illimitable progress, which again we cannot conceive as ever ceasing; and that mankind tends more and more to become a unity and its component parts more and more perfect. Turning now back to the animal world, we discover that no animal species, unless enormous epochs are considered, possesses any richness of culture; any notable variations in regard to individuals, groups, and periods; any discernible progress through the ages; or any approach to the co-operation of the entire species in time and space, as is to be witnessed in mankind. Nor is the thought exhausted by the preceding analysis, for it is borne in on us that it is misleading to speak of man as one social being among others, when in man alone not the group at a particular period of time, but virtually the species, or the totality of mankind past and present, co-operates and interacts. This, again, suggests that it is not the group which forms the human unit, but the individual who absorbs more or less the culture of the race and thereby becomes its representative. We finally reach by this route the conception of the individual as the culture-requiring, the social group as the culture-mediating, and mankind as the culture-supplying, unit, a conception of superlative significance for social theory and social practice, if true. There probably exist no limits to the benefits accruing from a scientific use of the imagination.

Besides being able to utilise reliable data accurately remembered, we should strive to exhaust mentally and factually the general and special conditions under which a fact presents itself, always avoiding unnecessary subtlety and alertly watching for the most promising explanations. There should be, for instance, no placid acquiescence in unanalysed catchwords. On

the one hand, men, *e.g.*, extol to the heavens "democracy", and, on the other, they judge "democracy" to be the grave of greatness; and yet there is almost never any very clear thought underlying either line of argument. Is there virtue in numbers irrespective of good qualities, or is there merit in an aristocracy regardless of any reprehensible characteristics it may possess? Should everybody, as in ancient Greece, be somebody, or should the masses simply hand over the government and themselves to experts? Should elections of various orders be multiplied and rendered more frequent, or should the citizens, perhaps once in a decade, elect perhaps one person for every million inhabitants to a Parliament and do nothing further? Should there be a small governing class in the world of politics and business, or should all interests (workers, employers, consumers) govern collectively through a comprehensive system of devolution?¹ Thus with the term "nature", where the expressions "human nature", "nature" (that which lies outside human nature), "a natural life" (in contradistinction to a conventional life), "natural scenery", "natural law", "nature" (in its most comprehensive sense), are repeatedly and disastrously confounded. Thus, too, with the noted phrase, "the elimination of the unfit", wherein the word "unfit" is rarely defined by Eugenists, sometimes signifying "physically unfit", sometimes "not successful in coining wealth or pushing to the front", and sometimes "not of service to mankind", its intrinsic meaning being "elimination of those unfitted for a particular environment", whatever be the position of this environment in the scale of human values.

Or examine the notion of "living in comfort", as conceived by some socialists. Here it is tacitly assumed that an immutable standard of comfort exists, and that with the advent of the socialisation of the means of production and distribution comfort will be universal when, as a matter of fact, the man with an income of £300 per annum agonises over his poverty, and he who disposes of £3,000 annually deems himself a wretch compared to his fellow who can expend £30,000 a year. Manifestly, comfort for the masses is either unattainable, or else a scientific and ethical view of comfort, equivalent to the scientifically determined simple life, should be advanced. (See also Conclusions 15 and 20.) A more judicious use of the imagination would likewise compel a reinterpretation of the onesided theory that men are mainly economically-motivated beings, or that radical changes in economic conceptions and processes can lead to no difference in the amount of wealth produced in any com-

¹ In considering the problem of democratic government and similar issues, we ought, in the first place, to think of what would happen if the democracy were highly educated. This would cut any number of Gordian knots, and probably reconcile most of those who genuinely care for the welfare of their country.

munity, because wealth and labour, as is frequently alleged, are interchangeable terms.

Finally, weigh the pregnancy of an expression such as "the family is the nation's unit". As a slogan it signifies substantially nothing; but allowing the imagination to pursue the consequences, we arrive at a comprehensive theory of the State and of economics. The object of wealth, according to this view, is primarily to secure the welfare of families, meaning by family mainly the two parents and the children, with their home. Wealth as such has, then, no value, and the wealth produced does not appertain to the individual producer, nor can it be legitimately disbursed save for promoting family welfare. The State similarly is not concerned with glory, power, honour, or wealth as such; but its policy should be shaped first and foremost by the requirements of the families constituting the nation. The home, then, is the true centre of national concern, and the production of wealth and the regulations of the State must subserve it. Domestic and child hygiene, home education, home work simplification, family concord and concord in the family of nations, become consequently all-important. The young should be trained for the life of marriage, and the husband should know much of the home as the wife should know much of the world, both being educated to appreciate the value of co-operation and the need for mutual respect. A male-directed world proves therefore an abortion, due to the men having come to confound the means (wealth) for the end (family welfare). Rightly considered, legislators and wealth producers should have for their principal object the creation and maintenance of well-provided and morally and æsthetically beautiful homes. The woman's work in the home assumes thereby a transfigured value, and she is also required to join the councils of the State, since she is best informed regarding that which most concerns the State. Erratic anti-family theories are hence discountenanced; old maids and old bachelors virtually cease to be as a voluntary class, whilst everything is done to maintain the numerical equality of the sexes; the man's ideal companion is his wife, and *vice versa*; home education and home management become matters of science; wealth production is directed to serve primarily this new conception of society; utopias are converted into eutopias; etc., etc.

Again, a more virile use of the imagination would cast doubt on some aspects of the theory of "genius" or inherited psychical capacity. That one man should be born with a perceptibly stronger or more delicate physical constitution than another, is easily understood; but how are we to picture to ourselves a "born" baker, cook, accountant, merchant, manufacturer, airman, lawyer, pianist, painter, musician, poet, saint, and the thousands of other "somebodies" who are said to be "born, not made", especially since, through the changes and developments

of culture, the implications of these terms deviate definitely from generation to generation! And this impossible view is further complicated by the theory that genius, like murder, will out, portraying a perfect social Babel where we find historically almost uninterrupted change and progress along a certain line. We have accordingly, to select an illustration, to imagine some genius born who "invents" unison music, another part music, another melody accompanied by a theme, another a musical theme without melody, and others more and more intricate themes, and practically never a genius appearing out of order. When we, therefore, consider the slow and orderly transformations historically undergone by the human arts, crafts, and disciplines, and the instruments they employ, it seems inexpressibly inept to propound the thesis that any one is born to accomplish a certain cultural task. The attempt reminds one of nothing so much as of square circles and round triangles. Here, however, the scientific imagination ends, and the demand arises for an ascertainment of the precise facts and factors involved.

Similarly with scores of catchwords in those spheres of cognition where the method of cool and full analysis is in sharp conflict with the courses of action proposed by passion and prejudice: everywhere these catchwords would be either rejected or would acquire fuller significance. Want of thought, more than scantiness of facts, is therefore not infrequently the cause of erroneous arguments and conclusions.

Active memory or imagination has thus its place in science; but it is rigorously limited in scope. If the particular fact under consideration at any time has not been thoroughly examined, or if the general facts are not familiar, imagination will be a busy mischief-maker. Scientific imagination is therefore concerned with what is securely established, and only aims at mentally reviewing the possibilities of extending a truth where it is not a question of generalising intimately known and already classified facts. The almost preternaturally slow advance of the knowledge of rays and of electric phenomena during the last fifty years, in spite of hosts of well-prepared intellects examining the phenomena, illustrates our contention that as a rule the scientific imagination does not roam, but tramps round and round a small and well-defined area. Only when prodigious masses of facts and generalisations have been collected, collated, and fused, is there room for a Newton, a Laplace, or a Darwin, to propose sweeping truths, or for a Sophocles or Corneille to write divinely. Here also the imagination is constrained to travel in certain prescribed narrow paths, decided by the countless established details and generalisations. The working hypotheses in the sciences form no exception to this statement, for they endeavour to interpret new facts by old facts, not new facts by novel or ancient fancies.

Scientific canons, therefore, demand that vigorous and rigorous objective examination of the facts and conditions should be accompanied by vigorous and rigorous subjective analysis and reconstruction of facts and conditions so far as known. The imagination is observable in action to the best advantage in the contriving of experiments, the drawing of deductions, and in the formulation of definitions.

§ 144. (D) CONTINUOUS METHODOLOGICAL CONTROL OF THE THOUGHT PROCESS.—The emergence of a felt need gives automatically rise to the problem of how it may be gratified. If that problem be ideally simple, as when we desire to touch some common object within convenient reach of the hands, the task of the intelligence is minimal; but when, for instance, we wish to comprehend the inmost nature of reality, satisfaction can only be secured, if at all, by the combined efforts of the thinkers of myriads of ages. Customarily, however, the problems posed by needs are such that a brief period of reasoning suffices to reach the conclusion or end aimed at. Thus when we desire to know how long it will occupy us to complete some piece of work, or what shall be our next task, or what we shall write to a colleague, or where we shall spend the vacations, or how we shall furnish our laboratory, or what shall be the contents of a memoir we contemplate presenting to a learned body, we reason and labour for a shorter or longer space of time, until a provisional or final decision is arrived at and the need is at least partially satisfied. In the process of reasoning the stimulating need is teleologically connected with a seemingly appropriate detail recollected, that with another, and so on with scores of memories, the controlling stimulus remaining as a constant, till the need is satisfied so far as circumstances permit. Reasoning being hence dependent on a succession of relevant memories, it is readily appreciated that, in the absence of deliberate and correct methodological training, countless causes may contribute to prolong and sophisticate a train of reasoning. On this account, the conclusion may be instantaneously reached; it may not be reached at all; or a partially or wholly false conclusion may be the fruit of our cogitations.¹

In a certain sense we are supposed to deal in this Sub-Section with the methodological process in its naked concreteness, as it proceeds from moment to moment in the act of ratiocination. As we have seen, the very fact that man's thought is as yet almost wholly unorganised, renders it abundantly clear that what takes place in the mind must vary alarmingly from individual to individual, that most of the ideas occurring are chance products, and

¹ See *Mind of Man*, ch. 4, for an analysis of the reasoning process. From this statement it will be seen that the laws of association by contiguity and by similarity are only secondary laws and do not account for the *flow* of thought.

that in downright honest meditations of an original character the process of mental synthesis is exceedingly circuitous and tortuous. Indeed, steady continuity of strenuous and correct thought becomes, in the circumstances, impossible, and the keenest efforts are often unaccompanied by dependable results. It is probably for this reason that in research work much is frequently made of little, that the initial stage is mistaken for the final one, and that thinkers and artists rapidly sink into mental grooves and abide therein for the rest of their lives. Anything to escape the primordial mental chaos.

Instead, therefore, of undertaking the unprofitable task of sketching in detail a moving mental anarchy occasionally relieved by the results of the application of a few precipitated cultural rules, we must demand the rationalisation and socialisation of thought on methodological models. Assuming this to be accomplished, say to the extent delineated in this work, this Sub-Section would draw the picture of the concrete process of thought when any particular problem—let it be the ethics of journalism or the theory of art for art's sake—is submitted for consideration. Unfortunately, the present author, who is forever learning and almost forever unlearning, cannot flatter himself that he is in a position to provide such an account. Whilst he hopes, for his own and for his readers' sake, that he has profited by his methodological enquiries, there is none of the consecutiveness and solidity in his concrete cogitations that one would have a right to look for, say, in the third generation of trained methodologists. All that he can therefore do is to propose that this enquiry be adjourned to the day when some one will undertake it who, under propitious conditions, has been, from infancy, thoroughly trained to reflect methodologically. Since thought consists, on the psychological side, of the cross-classification of memories, and since such cross-classification may be enormously simplified and systematised, it certainly appears as if the ideational thinking process of the future will be as superior to that of our day as our most highly developed machines exceed in efficacy the rude implements of primitive man.

§ 145. We will venture nevertheless on an illustration to elucidate the position. Some twelve years prior to this paragraph being penned, the present writer was responsible for a series of magazine articles on the moral education of children. He concluded the series by submitting how unreasonable it was to assume that systematic experimental practice should be required in all other subjects of the school curriculum where action was involved, and yet to deplore man's moral juvenility although neglecting systematic experimental moral practice. It being conceded that this criticism was partly suggested by the author's methodological activities, it may be admitted that, roughly speaking, the elaboration of the criticism entailed no difficulties

and that the article was written almost without halt in the author's thought. To this extent the methodological ideal is satisfied.

However, when his methodology inclined the author to the belief that a positive scheme should be developed, his mind became nearly a blank so far as this subject was concerned. Various items occurred to him, but, from his methodological standpoint, nothing worthy of being advocated as a system. For some ten years he recurred repeatedly to his favourite theme of conceiving an adequate plan, but in vain. During the last two years, however, he felt that just as his young children learnt to play on the piano, so should they become proficient in matters of right conduct; but still no luminous inspiration came to indicate how this was to be accomplished. One day, at last, whilst one of his children was playing the piano, a feasible solution dawned on him. It was to the effect that, accepting as a basis the golden rule enunciated in § 97, one might begin with posture training—sitting, standing, walking, etc., proceed to handshaking and simple salutation, then to simple conversation, and so forth. The general methods employed would be those in common use for all arts.

This outline scheme was, again, prepared within an hour or two in consequence of the application of methodological rules. Here was a definite and hopeful beginning. Incidentally, he pondered over the problem during the succeeding few weeks, and though generally satisfied with his discovery, it did seem to him that the art of conduct should be inculcated from earliest infancy, a conclusion having no doubt a methodological origin. Then it struck him that he had recently (*The Training of the Child: A Parents' Manual*, 1912; revised edition, 1919) advocated deliberate instruction and experiment in home education, and that this would solve his difficulty. Light, therefore, came, first, after a rule of life had been independently arrived at, simplifying and systematising the teaching to be given, and, secondly, when recollecting another recently systematised conclusion. So far as the problem is concerned of developing the system for common use, we need say nothing on this score here.

Assume now that the author had rigidly applied his fully developed methodological system. On its occurring to him to utilise the experimental method in the moral training of children, he would have, following precedent, at once decided on examining the nature of the experimental method in child training generally. This decision would have been followed practically immediately by the resolve to inspect the time table of a fully modern school (Conclusion 20). Trusting to recollection, until such time as verification was convenient, physical training, games, hand-work, drawing and painting, piano playing, and other subjects would have suggested themselves.

How was he to conceive the beginning of his experiments? Clearly, on the methodological basis of commencing with the

simplest matters, and proceeding, with growing age, to the most complex. And what were the simplest? Of course, those generally required of the very young. And what form were the experiments to assume? Those actually assumed with the young—first as games, then as interesting matter, and subsequently as love of the subject.

Beyond this, systematic procedure on the part of the experimenter, including regular times for regular periods, and systematic teaching as in schools, could be assumed forthwith as a matter of course.

Postulating much intimate experience with children and considerable reading in pedagogy, with methodological rules to aid, little difficulty would be experienced in drawing up a curriculum. Still, it would have been out of the question to have formulated a working scheme at once. He would have appealed to his memory for the simplest and most interesting actions to be acquired by children, following the day-to-day rule (Conclusion 19) in the effort to recollect, and these would have been only intermittently obtained. Discontinuity of the concrete thought process would have thus set in at this point, and he would have periodically returned to his task, alertly watching in the intervals for suggestive experiences and ideas, besides deliberately studying children, according to the day-to-day rule, and consulting books.

As he reflected over his task, it would have dawned on him—in fact, this is a methodological demand (Conclusion 20)—that he would be much helped by a simple and comprehensive rule of life. He would directly endeavour to recollect, methodologically, known rules of life, and presumably not find them satisfactory for his purpose. He would, for methodological reasons, desiderate a rule which would embody in a simple form the principal demands of the moral ideal. Again, we shall assume here that the subject was far from being a novelty to him. He would, accordingly, seek to remember such features. He had been charmed and impressed by the geniality of kindergartners, and had discovered the same virtue very widely in modern educational and institutional life. The kindergartners, too, triumphed by being intelligent, instead of being obsessed by routine solutions of difficulties or by authoritarianism. Automatically resorting to generalisation, he would extend intelligence to feeling and will, and thence to the utilisation of the whole of the mind. Here was a great step forward. However, methodologically, this would have led directly to the examination in a standard work on psychology of the lists of the constituents of the human mind. Acceptance and rejection of terms would have alternated, in accordance with the needs of the case and of the experience possessed. Other works on psychology would have been consulted with the same object in view, as well as books on ethics. Everything having to be carefully weighed, decision would have been repeatedly postponed. Satisfied at last with the elements

to be incorporated in the rule, the shaping of the sentence would commence. The author had spent over a hundred hours on determining on a convenient phrasing, whereas two hours, perhaps, would have sufficed if methodological rules had been throughout respected.

Many are the causes for the slow and erratic workings of the concrete intelligence. Methodological canons are only fitfully applied. Owing to a poor vocabulary and an anarchic memory, we are obliged to hunt for the right word. Fascinated by our ideas, we fail to employ terms in their normal connotations. Only partially trained in expressing ourselves correctly, it is with infinite pains we convey to others, or even to ourselves, what we mean. Not proceeding systematically, we fumble and stumble, and waste long stretches of time. Reaching the end of our scanty resources, our mind becomes a blank for a moment, and unconsciously the trend of our meditations has changed, and perhaps a considerable time elapses before we return to our subject. Or we build castles in the air instead of on the solid rock, ignoring or slurring over difficulties. Thus, in the absence of thorough methodological training, the mind is a medley of disjointed irrelevancies, and the quantity and quality of our cogitations are of the poorest. Indeed, it is probable that, so far as the concrete intelligence is concerned, there will be in the methodologically trained future a saving of perhaps ninety-five per cent. of time in enquiries.

If, then, observation is to be truly scientific, it is imperative that the concrete process of intellection, as it passes from moment to moment, shall be controlled and guided in all its aspects and phases by methodological canons of an irreproachable character. This presupposes adequate theoretical and practical methodological training from an early age until the mind grows into an ordered unity, responding automatically to the varied needs of a situation.

CONCLUSION 19.

Need of Ensuring Easy, Exhaustive, and Impartial Observation.

§ 146. This Conclusion professes to provide the assistance required to secure with ease abundant material for investigation, and to defeat subjective influences.

(a) In dealing with matters psychological, anthropological, historical, ethical, economical, meteorological, etc.—wherever changes are relatively rapid or where objects of the same class are likely to vary—a day-to-day rule is of conspicuous advantage. If, accordingly, we desired to learn something of the ordinary life lived by some tribe or nation, we pursue for some days the perambulations of a few average persons of that tribe or nation, from the moment they rise in the morning to the moment when they rise the succeeding day. We are thus in a

position to record accurately their normal habits, whilst otherwise we should be likely to furnish an account of a few graphic or accidental details. Corrections for locality, climate, season, age, sex, social stratum, special circumstances, would not, of course, be neglected.

(b) The just-mentioned rule may be extended to a season-to-season rule in those instances where the stages are seasonal, as with plants or some instincts and diseases, and beyond this to stages of life, as when certain physiological and pathological phenomena are connected more or less with an individual's age.

(c) The same rule may be also adapted to periodic changes and occurrences of any length, extensive or brief, as in astronomy or molecular physics, and

(d) to exhausting the varieties of any species or other object by continuously searching in space, time, and consciousness for divergences.

(e) Another rule refers to vegetation.¹ A plant may be studied from rootlets upwards; from the zygote stage to the time it decays; in the interrelation of its parts, and in its relation to soils, allied and neighbouring plants, altitude, moisture, atmosphere, light, bacteria, insects, larger animals, etc.

(f) A cousin of this rule comprehends animal life, though here permanent standpoints are to be chosen for classes rather than for the whole animal kingdom. Perhaps from head to tail or to extremities of hind feet, from conception to dissolution, from cell to systems of organs (alimentary system, circulatory system, etc.) and to the system of systems (the organism) would satisfy methodologically in a general way in respect of the higher animals and many of the lower. The nature and the interrelations between the diverse organs would be considered as well as relations to other members of the species, to closely allied species, to enemies, to food supply, to climate, and to the environment generally, animate and inanimate. (a) and (b) would, of course, apply to (e) and (f).

(g) A further group is concerned with objects which have a commencement, and which are not comprised in the previous groups. Thus a book is studied from beginning to end; so, too, an organic or other process, a law case, an experiment, a road, a concert, the history of an individual, of a reign, of an era, or of a country.²

(h) includes those aggregations of facts which cannot be distributed under any of the above headings. Here arbitrarily fixed standpoints are selected, that is, observing a ball, I fix upon some arbitrary point or continuous line as the place whence to proceed and whither to return in my examination.

¹ "If we are enquiring into the vegetation of plants, we must begin from the very sowing of the seed." (*Novum Organum*, bk. 2, 41.)

² For some instances illustrating this rule, see Bacon's *Novum Organum*, bk. 2, 5.

The concerted choice of the meridian of Greenwich felicitously illustrates this rule.

(i) asks that the completest possible inductions or enumerations should be aimed at. (Section XIII.)

(j) requires the universal application of the comparative, geographical, historical, generic, and evolutionary methods.

(k) emphasises that each ascertained fact or series of facts should be compared with other kindred facts regarding its relative condition, position, or importance—place, distribution, number, size, age, utility, value, preferability, etc., according to the table of Primary Categories—in order to circumvent marginal reasoning or unbalanced conclusions.¹ In matters social this would mean that “circumstances frequently alter cases”. Perhaps the majority of serious personal and collective differences in interpreting an individual’s or a group’s conduct in daily life, or generally, may be said to be due to disregarding unsuspected modifying circumstances. Grievous injustice is thus often committed. This is even truer in relation to matters pertaining to historical, ethnographical, and religious problems. In this connection we may appositely adduce the illuminating story of Confucius who, to the dismay of his disciples, counselled one inquirer, whom he knew, that he should “act on first thoughts”, and another immediately following him, whom Confucius was also acquainted with, to “act on second thoughts”.

(l) asks that we should ascertain (or, where in deduction or application inspection is not possible, imagine or realise) the nature of a simple or compound state or action (a substance, a school), first in its total normal condition, and then with regard to varying and exceptional circumstances. The confusion in reform movements, as we have repeatedly stated, is thus perceptibly due to envisaging only that part of the truth which is temporarily and locally exciting interest.

(m) demands that *we should become habituated, more especially in social problems, to (1) gathering ALL the facts, both pro and con, and objectively assessing their approximate value; (2) recognising that momentary and local feelings and views*

¹ “He ventured to think that an educated person should be one who knew what was evidence: when a thing was proved, and when it was not. Another attribute of the educated is the ability to know how many different interpretations could be borne by the same verbal proposition; what weight was to be attached to different authorities. Then an educated person should be able to say how far circumstances transformed propositions which were excellent at certain times and places but irrelevant patchwork when applied to all sorts of places. He had been led to believe that parallels and analogies from history were the most deceptive things in the world.” (Report of a portion of a speech by Lord Morley of Blackburn, delivered at the opening of the John Morley Laboratory, of the University of Manchester, Oct. 4, 1909.) “Male and female winged ants are strongly positively heliotropic, but as soon as they lose their wings their heliotropism ceases.” (J. Loeb, *Forced Movements*, p. 116.)

may be perhaps only of momentary and local importance; (3) taking into account the broad historical, and geographical aspects of the subject; (4) allowing for further developments in the near and more distant future; (5) connecting the problem, if possible, with wider, and also with more fundamental, considerations; and (6) weighing the comparative importance of the problem in order to determine the approximate place due to it at present in the domain of theory and practice.

(n) requires that we should compile a list of all the difficulties involved in the solution of a problem, and also a list of all reasonable solutions; and

(o) demands that we should incessantly and schematically re-examine for the special purpose of discovering new and independent facts, and pursue this course, until varied efforts, repeated at sundry intervals, yield nothing of moment. (See Conclusion 24.)

Methodical guidance of the above character is indispensable, especially if subjective errors are to be weeded out and if the enquiry is to be truly valid and exhaustive. In any particular investigation auxiliary rules should be, of course, formulated.

CONCLUSION 20.

Need of Searching for the Simplest Practicable Case.

§ 147. We should avoid plunging *in medias res*. If I desire, for instance, as a beginner, to learn the principle of the addition (subtraction, multiplication, etc.) of vulgar (or other) fractions, I ought not to write down a casual and arbitrary sum: $\frac{7}{8} + \frac{11}{7} + \frac{29}{83} + \frac{3}{17}$. I ought to select, instead, for study the simplest possible example, say: $\frac{1}{2} + \frac{1}{2}$.¹ The more important and complex the problem, the more imperative is it to start with the simplest practicable case. In this manner a ready solution will frequently be reached. Plato thus discussed a city instead of an individual, as exemplifying the question of justice in a simpler, because more conspicuous, form,² and for the same reason lecturers on physiology select the web of frogs, the ears of guinea pigs, or the combs of fowls, to demonstrate the circula-

¹ The simplest practicable case should be made the foundation principle in all teaching. Commencing with that case, the teacher would proceed to the case slightly less simple, and so on. It is also a deduction from this Conclusion that before passing from one stage to another, the scholar's former task should be thoroughly assimilated. Also, in learning a language, for instance, the supreme difficulty of accurate vocalisation might be overcome with relative ease by learning to enunciate, accent, and pronounce correctly a single paragraph of three or four lines, carefully comparing the enunciation, the accent, and the pronunciation with that of the language known. This could be followed by practice with meaningless rhymed syllables (e.g., ten, ben, len) and sets of syllables until proficiency is acquired.

² Plato, *The Republic*, bk. 2.

tion of the blood, whilst astronomers refer to the plane presented by the sea rather than to the uneven land when they desire to show the globular character of the earth, or call to witness the polar star to prove that the earth's axis does not suffer any material change with time. Physical geographers thus colour the map of the world to indicate now geological formations, now altitudes or temperatures, now barometric pressure or rainfall, now winds or ocean currents, and now the earth's vegetation, and anatomists present us in their atlases with a man now all muscles, now all circulatory organs, now all skeleton, and so on. In arithmetic the unitary method offers an illustration, as also the general formulæ in mathematics and the decimal system of measurement,¹ model experiments where one factor at a time is tested, especially an *experimentum crucis*, exemplify this Conclusion; and the simplest case includes mathematical or some other rigidly definite form of statement, and choosing for recollection, for study, for illustration, or for constructive purposes, a single typical example in connection with classes of facts. Thus, in comparing races, we may compare the European with the Australian bushman, as races culturally placed at the opposite sides of the scale, and in comparing their respective capacities we may examine their scholastic achievements under fairly identical circumstances, whilst in comparing individuals we may contrast an average person in intellect and moral attainments with a man of first-class scientific or moral standing. Darwin was well aware of the advantage of this Conclusion: "As soon as the idea of descent of species took definite shape in [Darwin's] mind, he determined, after deliberation, to take up the study of domestic pigeons. He selected these because the variations were more numerous and plainer, more of them had arisen in the historical period than is usual with animal groups, the material was abundant and easily accessible, etc." (Frank Cramer, *op. cit.*, p. 53.)²

¹ The English system of measurement and spelling and the Roman numerals are painful revelations of the opposite method. Compare also the French naming of some figures: 99 = quatre-vingt-dix-neuf.

² "In settling valencies, the greatest caution has accordingly to be observed by the chemist. He deals, if possible, especially in studying the elements with higher valencies, only with compounds of simple type containing if possible only one atom in the molecule of the polyvalent element, and he directs his attention to the compound which he can prepare with the highest valency exhibited, and in that compound univalent elements so far as possible occupying the available dynamic centres of the polyvalent element." (Benjamin Moore, *op. cit.*, pp. 91-92.)

"Long ago, physiologists learned that the quest for explanations of living activities lay along the line of investigating them in their most rudimentary expression." (W. A. Locy, *op. cit.*, p. 104.)

The *Report of the Indian Factory Labour Commission* tells how "one witness of long practical experience stated that any man would feel exhausted if he merely sat in a chair in some of the workrooms for eight or nine hours, the atmosphere was so foul". Given a regular succession of move-

§ 148. To venture on one somewhat circumstantial illustration. Suppose the question arises of the origin and development of language. We start with imagining the simplest case, and observe how far the facts depart therefrom. We assume that we hear the word “shrill” pronounced by a young child who is just able to read and does not know its import, and we conclude, to abide by the simplest case, that the word is and has always been pronounced precisely in the same manner by everybody in all ages. Similarly we assume the signification of the word to be as definite and immutable as its sound, and the number of words in the language to be constant. We now inquire how far the facts vindicate or refute our conclusion.

(a) We note, first, speaking historically, that no fixed standard of pronunciation exists, and that, accordingly, in a relatively short period of time, most especially before the era of writing and printing, the pronunciation of a word may alter measurably; that these alterations lead to further variations and adaptations; and that, therefore, other things being equal, practically every people, or comparatively isolated human group, comes eventually to possess a language of its own, which, with the ages, is necessarily transformed into another and another.

(b) We have assumed that speech consists of words always identically pronounced, and of nothing else. Applying again the simplest case by comparing the reading of an intensely dramatic passage by an uninterested child, on the one hand, and a passionate actor, on the other, we find that, at least to many a people, a different sound value is attached to the words according to their position in a sentence and according to the importance attached to them at a given time. We observe, further, sounds indicative of emotion accompanying the words, and we notice expressive facial gestures, and also gesticulations made with hands, etc. In some languages and in some localities we also trace a regular musical intonation in speech, especially when there is strong feeling. We establish these variations, from the spiritless word to the word intoned and accompanied by gesticulations. We note, finally, the sound value of words in songs and operas.

(c) We ask whether the word “love” has in reality a rigidly fixed meaning, and we learn that it is liable to alter in signification as in sound, and for the same reasons. On this account we discover transitional, transformed, supplementary, and multiple meanings. Experience we ascertain to be in a fluid condition, especially in earlier epochs, and we also learn that knowledge expands from age to age, originating with the veriest minimum, without there being, as there might conceivably be, an immutable method of changing or of adding words and

ments, etc., in a habit, they may be ascertained by noting on one occasion the first movement, etc., on a second occasion the second, and so on to the end.

meanings. Thus such terms as box, get, good, have, point, virtue, and scores of other words, especially such in common use, bewilderingly differ in meaning according to a particular context, and scarcely any word, in earlier ages, can be said to have possessed a single, definite, and fixed connotation.¹ Note affect (pretend), affected (unnatural), affecting (impressive), affection (love, illness); or, charging the enemy, charging the prisoner, charging a fee, charging some one with a mission, charging a gun, charging a boat. In our schools the two emphatic adjectives “ripping” and “rotten”, and the adverb “awfully”, replace literally hundreds of words among our budding writers of prose and poetry, and, likewise, the poverty-stricken vocabulary of the uneducated does not by any means argue that their store of ideas is correspondingly scanty. Assuming, then, a vocabulary altering in form in consonance with (a), we are further bound to take for granted that the meaning is also subject to mutation, since it, too, is fluid, mainly because of the fluidity of experience.

(d) If (a) and (c) contained the whole truth, the vocabulary of all languages would remain identical in magnitude, however its form and meaning varied. Examining, however, by the simplest practicable case, the vocabulary of the uneducated, we reach the conclusion that a few hundred primary words suffice in an undeveloped social state, as appears to be approximately the case among the Australian bushmen. We further note, on analysing, that the primitive vocabulary refers to the most common objects and to the commonest wants, and that the names of uncommon objects and abstract objects and wants are developed out of the primitive vocabulary. Thus certain sentiments may be adverted to, as blazing, flaming, fiery, incandescent, glowing, boiling, white hot, red hot, hot, warm, tepid, lukewarm, cool, chilly, cold, frigid, freezing, glaciated, arctic, icy, or we may alter concrete nouns to concrete and other verbs, as in *to screen*, *to mask*, *to veil*, *to cloak*, *to disguise* a person or thought. For this reason we are not surprised to find that poetry and metaphor remind us of a stage prior to cold prose which is almost void of imagery but self-explanatory. We also perceive that words become impercep-

¹ “‘Turn in’ is from this point of view one of the most astonishing words in a language exceptionally active in extracting the last ounce of utility from a single word. The verb ‘to turn’ has, in this its latest analysis, 47 main senses and 65 sub-senses. Then there are 25 senses on special phrases, such as ‘turn the scale’, ‘turn colour’, ‘turn tail’, and so on, and 16 combinations with adverbs, as ‘turn in’, ‘turn off’, ‘turn about’, and these too have their subdivisions—‘turn up’ is used in 27 distinct ways—so that, in all, the sense divisions of this busy little vocable number 286. And even then we have not begun on the substantive Turn, which fills 36 columns and, we are not surprised to hear, accounted for no less than three months of Sir James Murray’s valuable time.” (From a review of Sir James A. H. Murray’s English Dictionary, in *The Times Literary Supplement*, July 29, 1915.)

tibly modified to indicate certain differences in meaning, as in *love, loves, to love, loving, lovely, lovable, loveless, unloved, beloved*;¹ that words are doubled by prefixing or postfixing a word to create an added meaning—*blackbird, black bird, house-breaker, house breaker*, the prefixes and postfixes frequently losing their individuality and in their simplified form being often employed to coin new words—*co-operation, co-education*; that the same word differently pronounced or accentuated has sometimes a separate meaning allotted to it—*minute, retail*; that certain roots of words are fertile causes of new words, as *st*: *stable, stack, stall, stand, state, statics, stick, still, stock, stone*, etc.; that different parts of speech are freely formed one from another—*bicycle, to bicycle*; that names of persons and places are framed from the names of objects or actions and *vice versa*—*Stone, Taylor, mackintosh, boycott*; that natural sounds are imitated—doves *coo* and crows *caw*, or to take a striking series—*bash, clash, crash, dash, flash, gash, gnash, hash, lash, slash, mash, smash, splash, quash, squash, rash, thrash, trāsh*; that reasons of delicacy and temperamental causes generally are productive of new meanings—*deranged, demented, insane, neurasthenic, mentally disordered* for *mad*, or *all right, quite right, quite all right* for *right*; or compare the original and modern meanings of *pagan, knave, urbane, silly*; that certain forms and modes of combination are preferred—*efflux* for *exflux*; *the day before yesterday* for *foreyesterday*, that perfunctoriness and indolence impose heavy burdens on frequently used words, such as *have* or *get*; that aversion to repetition encourages diversity of expression in contiguous passages—*prodigious, colossal, immense, huge, gigantic, stupendous*. Following the simplest case, we gain in this manner considerable insight into the process by which a vocabulary of, say, a few hundred words becomes transmuted into a language boasting, perhaps, a few hundred thousand words expressing several hundred thousand meanings and capable of indefinite expansion.

The following are among prefixes employed in English: *a, ab, ad, after, alter, ambi, ana, ante, anti, arch, auto, back, be, bene, bi, bio, bis, bi, circum, con, contra, counter, de, demi, dia, dis, dys, en, enter, epi, equi, eu, ex, extra, for, fore, hemi, here, homo, hydro, hyper, hypo, in, in, inter, intra, intro, juxta, long, mal, meta, mis, mono, multi, non, ob, off, out, over, pan, per, peri, poly, post, pre, pro, re, retro, se, semi, short, sine, sub, super, sur, syn, tele, there, trans, un, ultra, un, under, uni, vice, with*; and these prefixes may be compounded as in *in-de-com-pos-*

¹ Here is a longer list—credible, credibly, credibility; incredible, incredibly, incredibility; (to) credit, credited, crediting, credit, creditor; (to) discredit, discrediting, discredited; creditable, creditably, creditableness; discreditable, discreditably, discreditableness; credulous, credulously, credulousness, credulity; incredulous, incredulously, incredulousness, incredulity; accredit, accredited, accrediting; credence, credential; credo, creed; credal, credally, creedlet.

able. Postfixes play, of course, a complimentary part in the formation of words. Many thousands of words owe thus their signification to affixes. The Latin verb *vertere* (*vertere, verti, versum*) supplies us through this channel with nearly three hundred words. Here is an almost complete list:

versatile, versatility; verse, verses, versicle, versicles; versify, versified, versifying, versification, versifications, versifier, versifiers; versed; version, versions; vertebra, vertebræ; vertebrate, vertebrate, vertebrates, invertebrate, invertebrates; vertex, vertices, vertical, vertically, verticalness; vertigo, vertiginous; vortex, vortices, vortical.

avert, averted, averting, aversion, aversions; averse, avversely, averseness.

advert, adverted, advertising, advertizing; adverse, adversely, adverseness; adversary, adversaries; adversary; adversative, advertence, advertency; inadvertent, inadvertently, inadvertence; advertise, advertised, advertising, advertisement, advertisements, advertiser, advertisers.

animadvert, animadverted, animadverting, animadversion, animadversions.

convert, converted, converting, conversion, conversions; convertible, convertibility; unconverted, inconvertible, inconvertibility; convert, converts; converse, conversely, converseness; converse, conversed, conversing, conversation, conversations; conversational, conversationally; conversationalist, conversationalists; conversazione, conversazione; conversable, conversably, conversant; reconvert, reconverted, reconverting, reconversion, reconversions; reconvertible, reconvertibility.

controvert, controverted, controverting, controvertible; controvertibly; controversial, controversially, controversy, controversies, controversialist, controversialists.

divert, diverted, diverting, diversion, diversions; divers, diverse, diversely, diversity, diversities; diversify, diversified, diversifying, diversification, diversifications; divorce, divorces, divorcee; redivert, rediverted, rediverting, rediversion, rediversions.

invert, inverted, inverting, inversion, inversions; inversely, inversely, inversed; reinvert, reinverted, reinversion, reinversions.

malversation, malversations.

obvert, obverted, obverting, obversion, obversions; obverse, obversely, obverse, obverseness.

pervert, perverted, perverting, perversion, perversions; perverse, perversely, perverseness; perversity; pervertible, pervertibility, impervertibility; perverter, perverters; unperturbed; repert, reperted, reperting, repertion, repertions.

revert, reverted, reverting, reversion, reversions, reversionary, reversal, reversals; reverse, reversely, reverseness; reverse, reverses; reversible, reversibility; irreversible, irreversibility; reverse, reversed, reversing, reversion, reversions; revertible, revertibility, retroversion; rerevert, rereverted, rereverting, rereversion, rereversions; rereversible, rereversibility, rerevertible, rerevertibility.

subvert, subverted, subverting, subversion, subversions; subversive, subversively, subversiveness; subvertible, subvertibility; resubvert, resubverted, resubverting, resubversion, resubversions; resubvertible, resubvertibility; insubvertible, insubvertibility.

tergiversation, tergiversations.

transverse, transversely, transverseness.

traverse, traversed, traversing, traversing; traversable, traversability; intraversable, intraversibility; traverser, traversers; retrace, retraced, retraversing, retraversing; retraversable, retraversability.

universe, universal, universally, universality, universalism, university, universities.

(e) From the above analysis we infer, through searching for the simplest case, that—given an insignificant vocabulary—innumerable languages, with extensive vocabularies, special

grammars, and rich meanings, will evolve necessarily and with astonishing rapidity.¹

(f) Needless to state that the application of the simplest practicable case to the problem of the nature of an ideal language should prove, as it is already proving in modern artificial languages, fruitful of good results. (See, however, § 205.)

§ 149. The whole of the above analysis suggests therefore the decided advantage of simplifying our problem as completely as possible, for this enables us with a minimum of effort to explore a subject systematically. There is scarcely a sphere of knowledge where the utilisation of the simplest practicable case is not applicable and of appreciable value, as, for example, in all cultural matters of a practical character where, instead of beginning forthwith *de novo*, we should first search for the best that has been accomplished in a particular or cognate direction. Thus, for instance, instead of assuming that armies and navies are necessary in the same sense as a police force is, we note that neutralised States exist and flourish without rattling or drawing the sword,² and that this is even truer of towns and provinces. Or if national sentiment is said to be indissolubly connected with a common tongue, the case of Switzerland is an apt reminder of the limitations of the generalisation.

§ 150. Another social problem of formidable dimensions might with advantage be approached by the same avenue—that is, the question of an adequate normal income for all. As is pointed out in Conclusions 14 and 15, the solutions customarily proposed are on this subject disappointing.

We might, then, proceed as follows. Having found that sterling material and efficient workmanship are really cheapest, we consider, say, the durability of a suit of clothes worn by a careful person. We repeat the enquiry in regard to each portion of the suit, and assume throughout (a) that we select colours, etc., which, other things being equal, are least affected by sun, wear, or fashion, and (b) that the individual has been trained to be careful with his garments and to undertake practically all minor

¹ The problem of an effective medium of lingual communication is not entirely solved until the question of the juxtaposition of words is considered. For example, two words may express one idea, as silver wedding, golden wedding, diamond wedding, and so with analogously framed word couplets and triplets. Even beyond this, the more cautiously we examine cultured speech, the more we discern the frequent associating of certain terms. Thus we often speak, for instance, of an invincible army, an implacable foe, an inexorable fate, an indomitable will, an inflexible determination, an unshakable conviction. Those who are best capable of expressing their thoughts clearly and forcibly, exemplify in a convincing manner this trend of selecting and fixing the most appropriate correlates of words. This process is, moreover, extended to sentences, as in idiomatic expressions, conventional formulæ, and polished diction. The ordinary dictionary, which by its method suggests that the nature and history of language are summed up in isolated words, is seriously misleading.

² This sentence was penned before the war.

repairs. Secondly, should circumstances favour it, we make an analogous study of wearing apparel in general, the food, drink, housing, furnishing, and recreation problems, where generally, and especially in respect of food and drink, much might be immensely and advantageously simplified and omitted, to the confusion of doctors and even of preachers. And, thirdly, we allow for certain other classes of expenditure, and for the fact that the entire problem is primarily a family problem—including mother, father, and, say, three children.¹

Having reached this point in our enquiry, we are prepared to venture on the second step, namely, to ascertain how much has to be deducted (*a*) for superfluous middle-men, (*b*) for inferior material and bad workmanship due to diverse social causes, (*c*) for methods of management, production, and distribution short of the most economical, and (*d*) for individuals not working—ultimately only children and the aged, since strikes, lock-outs, unemployment, idleness, and illness would be virtually annihilated in a well-ordered community. To simplify the enquiry, however, we only examine two or three articles and those the simplest and most important. We obtain, as a result, by judicious generalisation, approximately the true normal income necessary for an individual, a family, and a people. Until this calculation has been effected—and a competent and progressively-minded committee of men and women economists, with their eyes open and going directly to the facts, could accomplish it in a measurable time for all practicable purposes—we shall achieve little progress in the direction of discussing profitably the paramount social problem of the abolition of poverty and, with it, of riches and of unwholesome work and competition. In fact, this Conclusion might aid us in formulating a scientific utopia for our day, to realise which should be the combined task of statesman, reformer, and ordinary citizen. Incidentally, the conclusion arrived at would, in a practical manner, dispose of the problem of the much lauded and debated simple life.

The vexing wages problem, so simple in appearance and so complex in reality, may be approached by the same method. Suppose all engaged in production and distribution have the same income, and suppose the income is reduced 25%. Then, other things being equal, the price of all articles is reduced 25%; but the income having fallen 25%, the purchasing power will be the same as before, the lower price corresponding to the lower income. However, desire to earn 25% more, may lead to a 25% increase in output, which would mean a 25% decrease in price and a consequent 25% increase in purchasing power. Or disappointment at the 25% decrease in income may cause a 25% decrease in output, when the purchasing power will be reduced by 25%. Looking at the problem another way,

¹ For a list of family requirements, see § 127.

the employing class may absorb the whole 25% decrease in wages, when the workers will be simply 25% the poorer. Or the profits may be so high that a 25% lowering of wages may make only a 5% difference in price, when the workers' purchasing power will have fallen by 20%. Again, the already inadequate wages may be driven down 50%. The consequence may be that the efficiency of the workers is very seriously impaired through malnutrition, overcrowding, and the mental and material crippling of the new generation, the value of the output being reduced thereby by 50% or even 75%. Or the wages may be increased 25% or even 50%, and the output keep pace because of the vigour imparted to the working class by the higher standard of healthy living created. Furthermore, when average wages are considered, we may calculate that they must cover the ordinary current needs of a standardised family of five, plus perhaps 25% extra for various non-ordinary expenses and contingencies.

§ 151. Or examine the educational possibilities inherent in children.¹ The majority of our future citizens attend the publicly provided school from their kindergarten days to the age of fourteen, by which time they seem to have acquired only the rudiments of the elements of learning. The world in its physical, intellectual, moral, æsthetic, and evolutionary aspects, except for the barest surface, has remained, and will probably remain, practically a closed book to them. The position is slightly, though not appreciably, improved when we weigh the results obtained in the schools where the well-to-do send their offspring. If we desire, however, to apply the simplest practicable case to our problem, we shall search for an instance where a teacher had one or a few children in charge and was highly successful. This we find in the relation of James Mill to his son John Stuart Mill.² Here we meet with a magnificent result which suggests that the school, unless it is thoroughly reformed, is an extremely inefficient institution, and that the sooner it is replaced by home education,³ the sooner will the coming generations consist of men and women of culture and insight, instead of being composed, as at present, of a great mass almost void of any real ability, social enthusiasm, and refinement.

It will be averred, perhaps, that the younger Mill was by nature much superior to his fellows. To this two replies may

¹ This may be taken to comprehend early training generally. Beyond this, it also applies to youthful persons, though not to the same extent: "In Mr. Gantt's training of factory girls he has been able to make the large majority of each set into 'first-class workers', chiefly by the exercise of patience and tact." (M. and A. D. McKillop, *op. cit.*, p. 109.)

² See for a similar instance: *The Education of Karl Witte*, ed. by H. Addington Bruce, and for further illustrations Mr. Bruce's Introduction.

³ John Locke, in his *Conduct of the Understanding*, is emphatic in respect of the advantages of home education.

be tendered. First, John Stuart Mill explicitly and categorically denied that such was the case. Secondly, the present author has watched the early education of children in homes, and has reached the conclusion that any child of nine or ten ought not only to know, speaking generally, as much as children leaving the elementary school at fourteen, but vastly more, so far at least as real education is concerned. The secret is not a deeply veiled one. First, the child can be led to observe and know most of the simpler natural phenomena, to acquire manipulative dexterity, to make substantial progress in arithmetic and drawing, as well as to listen to simplified stories which would promote in him or her an understanding of, and interest in, all kinds of important problems. Secondly, the child is encouraged to read and re-read books, printed in large type and written in plain language and well illustrated, on many fundamental topics—astronomy, etheorology, geology, natural history, anthropology, psychology, history, geography, inventions and discoveries of a practical character, etc. If to this be added the older Mill's method of encouraging clear and thoughtful expression in speaking and writing of things learnt and considered, and a complementary training in morals and in the appreciation of things useful and beautiful, the outcome is quite beyond anything one could possibly hope for from the school in its present form, especially if we also include in our purview systematic methodological teaching of the type advocated in this volume.

Assuming intelligent direction, one fairly well prepared mentor could educate with facility, say, six children, until the age of self-education arrives, that is, several years before the average child now leaves the elementary school, after which period the teacher could as easily assist double or treble this number of children.

This analysis suggests several conclusions—that the present-day schools are, comparatively speaking, wofully inefficient; that the supreme aim of education should be to create in the young a love of truth, goodness, health, work, and beauty, and not merely to pump into them in class and during certain hours a given amount of "necessary" knowledge; that the schools should primarily succeed, if they are to succeed at all, in persuading children intelligently to read and re-read for themselves simply but ably written books on the leading topics of cultural interest,¹ to study problems at first hand, to become dexterous in every kind of manual activity, and to be habitually reflective and judicious; that they should obtain the co-operation of the home in order that the children are led to observe, examine, reflect, and act with decision; that the schools should raise their

¹ According to Darwin "there are no advantages and many disadvantages in lectures compared with reading". (*Life and Letters*, vol. 1, p. 33.)

standard of attainment for the different ages to that of James Mill's, and reduce the proportion of scholars under a teacher to about six for the earlier and twelve or more for the later stages; and, lastly, that the school is either doomed to be superseded partly or wholly by the home, or else should be transformed root upwards in accordance with the above demands. Indeed, from the point of view of a high conception of moral education, the present method of herding the children together, would be grotesque and criminal if it were not for the time being, perhaps, inevitable. Those who profess faith in mass education need to advance sterling reasons why it is necessary to congregate large numbers of children, and how it is possible in such circumstances to do justice to them either morally or intellectually. Here, also, the simplest practicable case should be applied.

§ 152. The simplest practicable case might be profitably divided into:

(a) centring an enquiry round one or a few instances which can be easily and exhaustively studied in respect of the aspects cited in our table of Primary Categories;

(b) scientific experiments where factors are isolated and where quantitative results are aimed at;

(c) use of instruments to aid the senses, and devising precise, refined, and powerful instruments (as Davey's battery, Faraday's magnet, the Ross telescope, Bose's magnetic crescograph, the motor driven hammer and crane, the giant airship and aeroplane, the towering factory chimney causing an enormous draught, etc.), besides instituting well equipped laboratories, experimental stations, and observatories;

(d) mathematical, quantitative, or definite form of procedure and statement;

(e) idealised statements (*e.g.*, the earth regarded as at rest and as having an axis, conceptual and real models, economic charts and diagrams, map projections and relief maps, sketches and simplified substitutes generally where necessary);¹

(f) scientifically established and universally accepted measures, formulæ, processes, methods, terms, etc., and preserving one or more standard measures, etc.;

¹ Simplification is very frequently resorted to in science. Here is a typical example: "In connection with the general problem of aerial vibrations in three dimensions one of the first things, which naturally offers itself, is the determination of the motion in an unlimited atmosphere consequent upon arbitrary initial disturbances. It will be assumed that the disturbance is *small*, so that the ordinary approximate equations are applicable, and further that the initial velocities are such as can be derived from a velocity-potential, or that there is no *circulation*. . . . We shall also suppose in the first place that no external forces act upon the fluid, so that the motion to be investigated is due solely to a disturbance actually existing at a time ($t=0$) previous to which we do not push our enquiries." (Lord Rayleigh, *Theory of Sound*, vol. 2, 1896.)

(g) approaching the unknown and remote from the side of the known and near (as in geology);

(h) selection of pure, conveniently large, and simplified instances (as in botany and physiology), and excluding or introducing single factors (as oxygen, moisture, heat, and the like) by suitable methods;

(i) observing, and experimenting with, myriads of instances, and continuing this for many years (as exemplified in Luther Burbank's enquiries); and

(j) proceeding by the law of averages and probability;

(k) ascertaining whether the senses or the instruments are at the time of investigation in normal condition;

(l) following Descartes' injunction, and dividing, as far as possible, complex problems into simple ones before investigating them; and

(m) isolating objects and forces, phases and circumstances, utilising here Mill's Canons of Difference and Residue (as in the experimental determination of food-stuffs necessary to plants or animals);¹

(n) aiming at the ideally simple and minimal in thought, movement, energy, means, material, conclusion, and statement (*e.g.*, the use of mercury instead of water in the barometer, the tonic solfa notation, the continuous twenty-four hours' system of measurement, summing the zeros as in 7×10^{23} , furnishing percentages, establishing international index numbers and units in all departments, romanising the Japanese and Chinese alphabets, fountain pens, rustless steel for knives); and

¹ Professor Bateson, speaking of Abbé Mendel's experiments, says: "In order to obtain a clear result he saw that it was absolutely necessary to start with pure-breeding, homogeneous materials, to consider each character separately, and on no account to confuse the different generations together." (*Mendel's Principles of Heredity*, 1909, p. 7.) In this cautious manner Mendel studied separately seven different characters of the pea, and his followers have even excelled him in thoroughness. So, too, it was only after animals were fed upon thoroughly purified proteins, fats, carbo-hydrates, and certain mineral salts, that the need of other essential food factors became evident, whilst, conversely, the addition of the latter produced a perfect diet. In physical and mechanical enquiries it is common to assume a fact to be far simpler than it is for the purpose of securing a point of departure. Hence we read in mechanics of points, particles, rigid bodies, and perfect fluids. When the solution for the idealised fact is obtained, less simple facts are studied until, so far as possible, the fact is known in all its complexity. That such is the procedure in geometry, with its perfect triangles, squares, and circles, is a commonplace. The use of the magnetic needle in magnetic experiments offers a further instance of circumventing the unnecessary complexity which arises when ordinary magnetic substances are employed.

The principle of the simplest case is involved in the principles of "least effort", "the line of least resistance", "the law of parsimony", and in the phrases "entities are not to be multiplied without necessity" (William of Occam), and "no more natural causes are to be assumed than such as are true and suffice to explain the phenomena" (Newton). (See a short article on "The Simplicity of Natural Laws", by Dr. C. H. Desch, in *The Positivist Review*, May, 1912.)

(o) preferring the simplest form of generalising and generalisations, deducing and deductions, postulating and hypotheses, verifying and verifications, defining and definitions, stating and statements, etc.

This Conclusion should, among other things, aid in revolutionising the methods of teaching in schools and colleges, and its results should be developed more especially by means of Conclusions 27 and 28.

CONCLUSION 20a.

Need of Degree Determination within and between Divisions, and, in this connection, need of searching for Pure, Normal, Minimal, Maximal, Parallel, Distantly Related, Seemingly Unrelated, Deviating, Morbid, Eccentric, Border, and Transitional Instances. (For text, see Conclusion 27.)

CONCLUSION 20b.

Need of Proceeding Dialectically, *i.e.*, need of searching in connection with any facts for what is Contradictory, Contrary, Opposite, Common, Disparate, Dependent, Interdependent, Supplementary, Alternative, Complementary, and Relative. (For text, see Conclusion 28.)

CONCLUSION 21.

Need of Habitual Alertness in order to discover Exceptional, Unobtrusive, and Unsuspected Facts, and need of Unremitting Concentration in Scientific Work generally.

§ 153. (A) HABITUAL ALERTNESS.—We should, according to this first part, bring into full consciousness what might remain an obscure or passing observation or reflection. Every hint should be tracked to its lair, and ours should be an expectant attitude of mind always prepared to find that a particular experience does not harmonise with our average experience, with another's experience, or with common experience. Everything we perceive should teach us something new, even when we have frequently encountered it before; we should keep alive the faculty of wonder, ever remaining sensitive, receptive, responsive, approachable, awake. We need to discourage lazy and hazy thinking, and be perennially on the alert lest we miss what is significant in a fresh or an unexpected connection. There should be an almost blind and instinctive desire to reach the whole of the fact and nothing but the fact, as well as to seize on what is of moment. Previous knowledge should be held suspect, and the supposition should be made that the form which common knowledge assumes is seriously incomplete. Examination and reasoning should be guided by the data rather than by preconceived notions, *e.g.*, instead of echoing the common assertion that the body renews itself every

seven years, we should be ready to find that some cells are replaced at frequent intervals, whilst others, such as the neural cells, never, or altogether, pass away; or instead of assuming that all twins intimately resemble each other, we might discover that there are two types—those closely resembling each other, developed from the same egg, and those plainly different, produced from two different eggs; or we might learn that “there are upland geese with webbed feet, ground woodpeckers, diving thrushes, and petrels with the habits of auks” (Darwin); or we might discover that a certain lowland plant transferred to a high plateau assumes the features of a certain highland plant and loses these when returned to the valley, but that the highland plant translated to the valley retains its highland characteristics; or experience might enlighten us about whispering galleries and opaque acoustic “clouds”, and not only teach us that cooling water begins to *expand* at 4°C. , but that in certain circumstances it may be cooled down to over ten degrees below 0°C. without freezing; or experiment might teach us that living larvæ might be produced by chemical changes from unfertilised eggs in the case of diverse species—starfish, sea-urchins, holothurians, and others; or alertness might enable us to connect avian polyneuritis with human beriberi, and also to assume that there may be life-endangering deficiency diseases which can be cured by the simple process of supplying what is lacking; or we might find, contrary to anticipation, that at the beginning of the week’s work and the first hour of work in the morning less is produced than after the first day and after the first hour, and that during the last hour before lunch and before leaving work in the evening more is produced relatively to some of the intervening hours, and that those working fewer hours produce, within large limits, correspondingly more. Seeming incongruities should be fastened on as possible new centres of departure instead of as matters to be ignored or explained away, as with the anomalous position of argon and iodine in the Periodical Table of the elements.¹ Darwin, according to his son, was above all things a believer in alertness: “There was one quality of mind which seemed to be of special and extreme advantage in leading him to

¹ “If some opposite instance, not observed or not known before, chance to come in the way, the axiom is rescued and preserved by some frivolous distinction; whereas the truer course would be to correct the axiom itself.” (Bacon, *Novum Organum*, bk. 1, 25.) Some famous instances of this kind should not be overlooked. When it was shown that water did not rise higher in a pump than thirty-two feet, it was contended that nature’s horror of a vacuum ceased at that limit; when it was demonstrated that the supposed loss of substance in combustion could be accounted for, it was argued that phlogiston possessed the characteristic of positive levity; and when Darwin proposed his theory of natural selection, attempts were made to modify the theories of special creation so that they might be in formal consonance with the results of geological and biological research.

make discoveries. It was the power of never letting exceptions pass unnoticed." (*Charles Darwin*, 1902, p. 94.) And his analyst writes: "The starting points of his investigations were frequently what seemed to other men interesting, but unimportant or inconvenient, exceptional facts." (Frank Cramer, *op. cit.*, p. 230.)¹ John Stuart Mill speaks in Chapter 4 of his *Autobiography* of "a mental habit to which I attribute all that I have ever done, or ever shall do, in speculation: that of never accepting half-solutions of difficulties as complete; never abandoning a puzzle, but again and again returning to it until it was cleared up; never allowing obscure corners of a subject to remain unexplored, because they did not appear important; never thinking that I perfectly understood any part of a subject until I understood the whole". Of Lord Kelvin, his biographer says: "He believed that light would come at last on the most baffling of problems, if only it were looked at from every point of view and its conditions were completely formulated." (*Lord Kelvin*, by Andrew Gray, 1908, p. 306.) "It was a happy thought of Glauber", writes Sir John Herschel, in his *Discourse*, "to examine what everybody else threw away." (161.) "In case any exception occurs, it must be carefully noted and set aside for re-examination at a more advanced period." (172.) "It is commonly stated", writes Thorpe, "that the exception is a proof of the rule. The history of science can show many instances whereby the rule has been demolished by the exception. Little facts have killed big theories, even as a pebble has slain a giant." (*Op. cit.*, vol. 1, p. 85.) Sir Michael Foster, speaking of the scientific worker, declares: "He must be alert of mind. Nature is ever making signs to us, she is ever whispering to us the beginnings of her secrets; the scientific man must be ever on the watch, ready at once to lay hold of Nature's hint, however small, to listen to her whisper, however low." (*Presidential Address to the British Association*, 1899, p. 16.)

We should, furthermore, be alert in our thought, utilising all the serviceable memories and rapidly elaborating as many provisional conclusions and deductions as the circumstances permit.

Primarily we need to be guided by the consideration, illustrated in Conclusion 19, that *what obtrudes itself is most generally indifferent scientifically, and that what is significant scientifically has to be searched for in unsuspected quarters*. Common observation would never have revealed to us the nature of the white corpuscles or phagocytes which, according to Metschnikoff,

¹ Adverting to how Sir William Crookes was led to his vacuum tube experiments, Sir William Ramsay (*Essays Biographical and Chemical*, 1908) remarks: "Here again we see the advantage of following up small trails; they may widen to great and most important roads." (P. 124.) And he adds: "I believe that Röntgen's discovery arose from an accidental observation that a box of photographic plates left near a Crookes tube became 'fogged', and he too had genius to follow up this clue." (P. 125.) Poincaré has a suggestive passage on this point in *Science et méthode*, 1908, p. 311.

are our protection against certain dangerous bacteria, nor would observation of this kind have disclosed to us the existence of countless classes of such bacteria, much less that in many instances the malignant bacteria are carried and nursed by some animal or insect, as in the case of malaria, the "Nagan" horse and cattle disease, sleeping sickness, and the plague. Nor would ordinary reasoning have led us to observe that the telegraph wire guides, but does not carry, the electricity, that telegraphic messages might be sent without any conductor, or that it might be possible to be in London and yet make one's voice heard in Paris or Rome. And it required alertness for a medical student to notice that ether numbs pain, or for some one to identify the specks of yeast with vegetable life, to be struck with the nucleus of the cell, or to suggest that lunatics should be ordered to bed.¹ The longer one revolves such discoveries, the more one is astonished that most of them should not have been made long ago, and the intenser becomes the conviction that, when once a scientific methodology is established, obscure or delicate hints will seldom be neglected by even amateur workers in science.

However, alertness is not less a virtue in the domain of practice, and this is admitted by business men. Yet so far as officialdom is concerned, it is largely, allowing for certain honourable exceptions, in an arrested stage of development. Here we have, so to speak, an exemplification of the workings of the more or less primitive mind. The typical official reasons that in lack of caution lurk dangers, and he thus arrives at the suspicious conclusion that in doubtful matters he must do no more than he is absolutely bound to. Risks—and there are risks in practically everything—are therefore to be avoided at all costs, an attitude which every business man knows spells disaster, if not ruin. Similarly, everything tends to be organised on the Noah's ark principle. Every official has assigned to him a narrowly and arbitrarily circumscribed sphere of action, and a hierarchy of public servants is established with definite inelastic responsibilities and human relationships reduced and degraded to an exchange of minutes. Initiative, adaptability, and progress are hence seriously obstructed, and an organisation is created which will not only do nothing that is wrong, but do nothing beyond what it is forced to do. Hence the govern-

¹ Catalysers and enzymes form an excellent illustration of our thesis, for nothing save dogged alertness would have revealed them. Here are some examples relating to catalysers: "A mixture of oxygen and hydrogen immediately explodes when it is brought in contact with platinum black. Common coal gas inflames when brought in contact with finely divided platinum. Sulphur dioxide is by the same agency quickly oxidised to sulphuric acid. Hydroperoxide is rapidly split into oxygen and water when in contact with platinum black. In all these cases the quantity of platinum black is not diminished after the reaction, and the products of the reactions are never any of the platinum compounds." (Frederick Czapek, *op. cit.*, p. 84.)

ment machine is too frequently a gigantic treadmill where mighty efforts produce intangible results. The intentions of the bureaucrat, we perceive, are immaculate; but he is not alert enough, and virtually strangles the great hopes reposed in him. Not until the government machine has been converted into an organism, will it be an instrument of social progress. An alert community will insist on, and carry through, a radical reform of public services, with the object that these services should successfully compete in efficiency with the best commercial, industrial, and scientific services.

Habitual alertness, lastly, will be immensely aided by the conscious assumption that all variations, however common or slight, as in the size, shape, foliage, flowers, vigour, or resistance of plants, should be regarded as demanding elucidation and explanation, and as possibly exemplifying far-reaching principles.

§ 154. (B) UNREMITTING CONCENTRATION.—The mind should be ceaselessly concentrated in all scientific work, and never be allowed to be greatly or entirely relaxed. Only in this manner are we likely to escape superficiality and error, and make certain that the wheel of progress shall perpetually revolve and advance, for with the diverse mental powers unstrung, we become mechanical and our work is of necessity indifferently performed. The thinker reflects strenuously without intermission, and he who would be a thinker must needs act thus. To contend, therefore, that thought is only requisite at certain defined critical moments in an enquiry, is to display inadequate insight into the complexity of phenomena or into the procedure of successful men of science. Novel facts may present themselves at any moment, and old facts may appear in a new light when a concentrated mind observes them. Every situation or problem we are confronted with ought to call out our best energies of thought. *There are no indifferent details, no automatic parts, one might say, in a scientific enquiry, any more than in an up-to-date business transaction or in true art.* It is probably a grave misapprehension to assume that the thinker need exercise no effort as a rule, and that he need only think at intervals. In all affairs of life the contrary is true, and the more strenuous, and continuously strenuous, we are, the more our powers will develop, whilst habitual absence of strenuousness will reduce our capacities to negligibility. It is likewise an error to suppose that mental effort is exhausting or impossible to the average mind; for, most probably, the normal individual may become, through practice, accustomed to hard mental as to hard physical exertion, the harder the more intelligently and the more ceaselessly he practises.

Our conclusion is, then, that it is the distinguishing mark of a properly conducted scientific enquiry that in all its phases habitual alertness and unremitting concentration are exhibited.

CONCLUSION 22.

Need of Collecting the Largest Number of Leading Facts and Ascertaining the Unlike as well as the Like.

§ 155. (A) *ABUNDANCE OF LEADING FACTS*.—Out of the multitude of methodological Conclusions it would be difficult to select many which are more gravely sinned against than the present one, and with such dire consequences. For this reason, we encounter references to such a need in several of the Conclusions. It is the besetting fault of the average thinker of to-day to assume that the one or few facts which he professes to have discovered, are all the facts relevant to the issue.¹ Thus the student of methodology has repeatedly occasion to observe that whole systems of thought are grounded on some few, out of a vast number, of relevant facts. Instead of patiently collecting all that is material to a subject, the majority of investigators shout Eureka! when they are only at the threshold of their preliminary examination. And to aggravate matters, it is common for one investigator with a handful of facts to oppose another who is equally placed, on the assumption that the two handfuls are necessarily irreconcilable and that one of the handfuls comprises all the needful data. Naturally, therefore, those inquirers who regard their task as completed when it is scarcely begun, contribute very little to intellectual progress, and hence it happens that advance is drearily slow and proceeds by an interminable series of corrections of older views until at last, in zigzag fashion, the comprehensive truth is reached. Such a mode of progression is assuredly as wasteful as it is questionable.

The inquirer should accordingly assume that only a prolonged investigation yielding an extensive number of material facts justifies any important or definite conclusions. For example, the present author might have been satisfied with two or three of the items in the heading of Conclusion 25. Instead, he did not cease for many years to attempt to add to the list of qualifications, and he has no doubt that additions of equal and greater importance to those quoted are possible. Similarly, with the sub-points in Conclusions 19 and 20, or with the number of the Conclusions, or indeed with the general text of the Conclusions. Everywhere where it is not a question of direct observation, of generalising, or of more or less manifest relations, as in Conclusions 27 and 28, nothing remains but persistently to supplement material details and resolutely to dismiss the idea of finality. If these details can be afterwards welded together and augmented by a process of generalisation or deduction, this is a matter for felicitation, but separate important facts apposite

¹ "That fashion of taking few things into account, and pronouncing with reference to a few things, has been the ruin of everything." (Bacon, *Parasceve*.)

to any investigation should never be hypothetically supposed to be scanty in number or non-existent, because they are difficult to procure. For example, Lavoisier imagined that organic compounds were combinations of carbon, hydrogen, and oxygen. Experiment has added to these in the course of time not only nitrogen, but about a dozen other elements.

Another instance. How far can we legitimately speak of common interests between nations? We might notice the outstanding case of the imposing national imports and exports, and rest satisfied therewith. Or we might add to this emigration and immigration statistics and the legions of individuals travelling in search of enjoyment, health, study, and profit. Pressing on, we might with advantage refer to the hundreds of international associations and their congresses as well as to the internationalisation of the sciences and the arts. If, however, we aspire to a truly adequate conception of common interests between nations, we should, according to Conclusion 25*i*, run systematically through the physical, biological, and cultural sciences, together with the arts, crafts, and customs, as epitomised, for instance, in Conclusion 33. The haphazard selection of one or a few unconnected particulars must be eschewed at all costs.

Here is a further example. In reconstructing industrial processes along scientific lines, attention was initially focused on the most prominent factors—elimination of unnecessary movements, of slowness, and of sensible fatigue. If, however, we desire to be veritably comprehensive, we commence at the beginning—intention to perform a task, willing it, sensing material constituents or recollecting mental ones, studying simplification, rapidity, pauselessness, energy, and fatiguelessness of movements, allowing for thought, volition, and feeling throughout, and enumerating completely the principal external factors influencing the quantity and the quality of the output—as found in Conclusion 10—and continuing thus right to the end. Only in this manner can we ascertain whether some valuable constituent has not been overlooked. Moreover, there is no sufficient methodological reason, apart from the absence of a methodology, why the systematic enumeration of factors should not have been undertaken at the very inception of the scientific efficiency movement.

Similarly, with the general problem of dietetics. Instead of fastening on one or a few important aspects, there should be an endeavour to collect all that is relevant and of moment. Such aspects might be considered to be (a) food containing the necessary nutritive ingredients (including vitamins) for ensuring and maintaining robust health; (b) such food as is most easily digested and most fully absorbed; (c) clean and well prepared food cleanly served; (d) keeping close to the minimum required for sound health and arranging for the

largest suitable breaks between meals; (e) studied, but approximately minimal, variety at each principal meal and otherwise and at different seasons; (f) proper mastication, no hurried eating, and some rest after meals; (g) eating with pleasure; (h) good teeth; (i) allowance for physiological idiosyncrasies; (j) proper feeding from infancy; and (k) obedience to the other principal demands of hygiene, more especially pure air all day long, including good ventilation by day and night; sufficient but not excessive mental and physical exercise; adequate sleep during the night; protection from extremes of cold and heat; no dissipation; no intoxicants, narcotics, etc., affecting the organism deleteriously; avoidance of disease from infancy; no profound anxieties; and a cheerful temperament. Once a fairly exhaustive statement is arrived at, the different classes of facts can be evaluated, considered one in relation to the other, a comprehensive statement formulated, generalisations and deductions made, and further dietetic studies commenced on that basis.

Likewise, the agriculturist will study the local climate, the local soil, the plants and varieties best suited for the local soil, the best manures, questions of drainage and irrigation, agricultural machinery, efficient labour supply, local and distant markets and their requirements, costs, and much else.

Lastly, instead of seeking to explain the economic crisis following on the war by one or two causes, we should be well advised to draw up an exhaustive list of the alleged influences, assume that a large number of them are of vital importance, and that the forces adduced act and react on one another. Here is such a list, startlingly formidable in character, which could be, however, reduced by classification (as, *e.g.*, deficiency in commodities and workers due to the war, etc.):—

Lack of coal, raw materials, transport, machinery, commodities generally, and foodstuffs; lack of capital (including watering of capital); lack of credit intra-nationally and inter-nationally; lack of markets (due to blockade, adverse exchange, poverty, etc.); exhaustion of stocks during war-time; destruction of coal mines and of much other property; dislocation and disorganisation through changes of boundaries; new frontiers interfering seriously with railway systems of transport; customs barriers; serious discriminations against certain classes of imports; worn-out plants; readaptation of commerce and industry to peace conditions; government restrictions on trade; disorganised exchanges preventing ready interchange of goods (low exchange prevents buying and high exchange selling); excessive speculation as regards commodities and in floating companies; inflated and depreciated currency; continued large expenditure on war forces and large government expenditure generally; extravagance in living and little saving; enormous burden of public debt and heavy expenditure on pensions; heavy and excessive taxation crippling and discouraging industry; high wages and high cost of living; rise in prices, and driving up and keeping up of prices; wholesalers, retailers, and consumers waiting for lower prices before buying; profiteering; fear of repudiation of liabilities by firms and nations; lack, or presence, of a gold basis; wars and fears of wars; blockade of Russia; non-declaration of reparation amount to be asked from Germany; withholding of stocks

from the market and of credits by banks; governmental absorption of bank credits; over-production; ca' canny; eight hour day; millions of people killed in war and by influenza epidemic; lower vitality of workers generally, owing to malnutrition and want generally; large masses of totally and partially disabled; large numbers nervously and physically injured during the war without being "disabled"; lower proportion of the physically fit, through the physically unfit having been rejected by the recruiting officers; decrease in the proportion of skilled workers and managers, and decrease in skill through the diminution of apprenticeship and technical classes during the war; decrease in intelligence through inferior education or no education during the war; many more widows with children and many more children proportionately; smaller total population, more especially in respect of workers (there being proportionately many more "families" without wage earners than before the war); younger workers (between 20 and 30) reduced in excessive proportion; general and deep dissatisfaction of workers, leading to negative interest in work and to consequent reduced output; uncertainty among manufacturers and merchants, leading to decrease of enterprise; and exploitation by certain countries of the necessities of other countries.

§ 156. (B) SEARCH FOR UNLIKE FACTS.—Given a certain topic of enquiry, say that of the function of government, we commence by searching as much for unlike facts and generalisations as for like ones. Our only concern is to exhaust all the material facts, partly because such knowledge may aid us later in obtaining generalisations by the detection of certain underlying intrinsic similarities in different classes of facts, and partly because it is, in any case, desirable to be acquainted with important facts.

In agreement with this, we require accurate and numerous means to assist us in securing a variety of details, generalisations, and deductions. If, for instance, the sense of touch presupposes immediate contact with objects, we may ask ourselves whether the other senses also require immediate contact. Should we discover that each sense has a separate means of coming into contact with reality, this would equally constitute a positive result. Or if we apply Conclusion 28, and obtain as regards related classes of facts contrary or contradictory results, these also may claim to possess positive value. Or we can utilise the method of contrast. If certain factors actively assist a process, we may seek for such as actively impede it. Or if we find one means employed in one connection, we may look for different means in this and in disparate connections. Or, to take a specific example, if we find beef-fat to contain fat-soluble A, we should be prepared to discover that lard is devoid of it. In other words, we apply Conclusions 27 and 28, and whatever other apposite Conclusions we have reached, not only to abstract higher generalities, but sheer differences. The first step, therefore, in every portion of an investigation—observing, generalising, deducing—must be to reach the utmost variety within a given unity, and the second step should be to prove the existence of the greatest unity within the given variety.

CONCLUSION 23.

Need of Exhausting Classes of Facts, their Conditions, and the Uniformities accompanying them.

§ 157. (A) *EXHAUSTING CLASSES OF FACTS*.—In his famous example of the investigation of heat, Bacon plainly implies that classes of facts should be exhausted where practicable, and in connection with the problem of effective observation scientific methodology demands that the enquiry should proceed till no new classes of relevant and material facts can be found. With Prof. Karl Pearson we should cease to look, initially, for one principal factor only, and examine all possible factors, and with Prof. Schuster we should inspect all possible frequencies.

§ 158. (B) *EXHAUSTING CONDITIONS*.—The conditions should be also exhausted. We should endeavour to examine all the conditions that we can possibly discover or utilise, and we need to be searching for new classes of conditions long after the first or second success or failure to discover any.

§ 159. (C) *ACCOMPANYING UNIFORMITIES*.—We should ceaselessly aim at ascertaining accompanying uniformities. That earthquakes proceed along earth fissures and are specially common and disastrous along ocean borders, mountain districts, and around active volcanoes; that volcanoes are mostly situated near the sea; that the daily retardation in the tides approximately equals the daily retardation of the moon, and that the height of the tides locally is determined by sundry local factors; that the configuration of a district regulates to some extent the rainfall, and that its configuration is frequently determined by its water courses; that day and night are caused respectively by the presence or the absence of the sun; that the bisons and other hoofed animals are, perhaps, related as cause and effect to the treeless spaces which they haunt; that the prevalence of rats coincides with the occurrence of certain epidemics, and that a certain relation obtains between stagnant pools and mosquitoes, on the one hand, and open dustbins and houseflies, on the other; that those addicted to alcohol have less power of resistance to disease; that relatively moderate but moist heats are far more oppressive than those of hotter but drier localities; that the exceeding dryness of hot desert climates causes the air to be hotter during the day and colder during the night, as compared with more humid climates; that “the presence of trees reduces the temperature of the atmosphere, whilst radiation is hindered at night, that trees thus produce the effect of equalising temperature, and, by keeping the atmosphere moist, they induce the fall of rain”; that the physical features of a district or a country (*e.g.*, the presence of extensive coal measures) determine in no small degree its social features; or that home education reacts on school education

and one art on another, are some cases in point illustrating the need of allowing for concomitant uniformities. (See also § 139.) Diverse anomalies in astronomical data have thus been removed by the assumption and subsequent discovery of correlated facts. The following passage from Darwin (*Origin of Species*, ch. 3) well exemplifies the need of heeding accompanying uniformities:—

“I have found that the visits of bees are necessary for the fertilisation of some kinds of clover; . . . [but] humble-bees alone visit the red clover, as other bees cannot reach the nectar. . . . Hence we may infer as highly probable that if the whole genus of humble-bees became extinct or very rare in England, the heart's-ease and red clover would become very rare or wholly disappear. The number of humble-bees in any district depends in a great degree on the number of field-mice, which destroy their combs and nests, and Col. Newman, who has long attended to the habits of humble-bees, believes that ‘more than two-thirds of them are thus destroyed all over England’. Now the number of mice is largely dependent, as everyone knows, on the number of cats; and Col. Newman says: ‘Near villages and small towns I have found the nests of humble-bees more numerous than elsewhere, which I attribute to the number of cats that destroy the mice.’ Hence it is quite credible that the presence of a feline animal in large numbers in a district might determine, through the intervention first of mice, and then of bees, the frequency of certain flowers in that district.”

The more fundamental accompanying uniformities should, however, receive our first attention. An ordinary plant, for instance, depends on the relative compactness, and on the ingredients, of the soil; on sunshine; on the surrounding warmth, especially at certain seasons; on the oxygen and the carbonic acid of the atmosphere; on the visits of fertilising insects and, perhaps, on other plants and animals; on nitrifying bacteria; etc. Animals also cannot live without free oxygen in their environment, a certain degree of surrounding warmth, and light, food, freedom of movement, and other external factors. And what is true of classes of living beings of a higher or a lower category, is true in regard to individuals and their component parts.

Moreover, the most fundamental accompanying uniformities require to be pondered over from time to time. It is manifest that if we imagine the degree of heat to be sufficiently raised generally, all solids and liquids will turn into gases, and the chemical elements will be decomposed into some simpler form of matter, whilst if we conceive the degree of heat to be sufficiently lowered generally, all gases and liquids will turn into solids, and life and chemical changes would cease. In this connection it is well to take, periodically, a long view, casting our glances forwards and backwards into the eternities in connection with any given subject. Similarly a grave disturbance in the amicable relations between our globe and the sun, or a lapse from “neutrality” on the part of one of the nearest stars, would be of momentous consequence to

everything on the earth. Thus, taking a very comprehensive relativist view, Einstein questions the absolutist conception of space and time, and deduces from gravitational influences the curvature of light rays and of spectra reaching us from distant stars.

CONCLUSION 24.

Need of a Critical Attitude, of Provisional Treatment, and of Repeated Testing, throughout the Process of Enquiry.

§ 160. (A) CRITICAL ATTITUDE.—The critical attitude should never forsake the inquirer. However cogent his reasons for the conclusions which he has reached, he should still ceaselessly call everything in question. Some few observations may be erroneous, the argument may require buttressing, or an unsuspected fallacy may vitiate the entire solution. The assumption needs to underlie his procedure that the real and complete truth will only emerge after a repeated re-inspection of the facts, a repeated re-testing of his conclusions, and after having collected and collated a considerable number of truths. Alertness, and not formal scepticism, is the attitude desiderated here.

Much of the thinking in the past has been critical, not of oneself but of others. Men have written voluminously to prove that some one else's theory is defective, and have at the same time assumed that their own point of view, conceived as the sole alternative, is thereby recommended, if not substantiated. They have been, in fact, as stern and unreasonable towards others, as they have been excessively lenient and conciliatory towards themselves. Speaking generally, any discussion or criticism of others should be incidental, and in such discussion or criticism there needs to be full recognition of the ease of misjudging, and the difficulty of dealing out justice to, others. Extensive criticism is rare in the established and typical sciences, and presupposes on the whole critical rather than scientific acumen, since the removal of errors by criticism gives generally place to other errors rather than to truth.

§ 161. (B) PROVISIONAL TREATMENT AND REPEATED TESTING.—Whilst attempts within reasonable limits to exhaust any part of a problem need to be made even in the incipient stages, there should be the further assumption that the results arrived at are provisional, and that we should revert frequently to a re-examination with a view to perfecting or modifying the conclusions. This provisional treatment renders subtlety and speculation superfluous, and the repeated investigations, in the light of connected examinations, are sure to alter many of the earlier inferences.

Darwin's practice supports our contention. "Some of the most important explanations under his theories did not occur to him until years after he had begun their study. . . . His work

on 'The Expression of the Emotions', began in 1838 and closed in 1872; 'Insectivorous Plants', 1860–1876; 'Vegetable Mould and Earthworms', 1837–1881." (Frank Cramer, *op. cit.*, pp. 79–80.) And his analyst reflects Darwin's attitude in the following comments: "Nothing can be so demonstrative as the relative permanence of work that has been done slowly and work that has been done with promptness and apparent vigour. The latter almost invariably takes a very subordinate place in the literature of the subject when once that subject is completely worked out. . . . Where speed is felt to be necessary, a vast outlay of energy is frequently required to discover what with more time would almost come of itself. With the attention steadily fixed, time brings to bear multitudes of facts that would otherwise be lost." (*Ibid.*, pp. 77–78.) And, again, epigrammatically: "Time, as well as reason, is the handmaid of science." (P. 80.)

Psychological and objective arguments emphasise the need of this Sub-Conclusion. The very effort required in circum-spect examination is fatiguing, and re-examination is therefore expedient, whilst repeated recurrence will tend to remove sundry objective limitations and provide an opportunity for fresh ideas to play round the subject. We are also likely not to be obsessed by fixed concepts, and to note errors that blurring familiarity and a crowd of irrelevant and obtrusive particulars, which will be forgotten in the course of time, screened from us. On this account we should not proceed without appreciable breaks in an enquiry. (Conclusion 7, last par.) Naturally, too, some considerable period should elapse before we close an enquiry, in order to prevent precipitate decisions and allow ample time for re-examination under varied conditions.

Moreover, in the interest of true scientific progress, it is indispensable to apply these precautionary measures to existing collections of knowledge, for it has not seldom occurred that propositions said to be long and fully established are seriously infected with error. Science does not recognise any infallibility in its devotees, even though they may have flourished centuries ago.

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§ 162. It will be useful, now that we have concluded our study of Observation, to append a long excerpt from Darwin, the great observer and generaliser, to illustrate in detail the extreme need of cautious procedure:—

"Cell-making instinct of the Hive-Bee.—I will not here enter on minute details on this subject, but will merely give an outline of the conclusions at which I have arrived. He must be a dull man who can examine the exquisite structure of a comb, so beautifully adapted to its end, without enthusiastic admiration. We hear from mathematicians that bees have practically solved a recondite problem, and have made their cells of the proper shape to hold the greatest possible amount of honey, with the least possible consumption of precious wax in their construction. It has

been remarked that a skilful workman with fitting tools and measures, would find it very difficult to make cells of wax of the true form, though this is effected by a crowd of bees working in a dark hive. Granting whatever instincts you please, it seems at first quite inconceivable how they can make all the necessary angles and planes, or even perceive when they are correctly made. But the difficulty is not nearly so great as it at first appears: all this beautiful work can be shown, I think, to follow from a few simple instincts.

"I was led to investigate this subject by Mr. Waterhouse, who has shown that the form of the cell stands in close relation to the presence of adjoining cells; and the following view may, perhaps, be considered only as a modification of his theory. Let us look to the great principle of gradation, and see whether Nature does not reveal to us her method of work. At one end of a short series we have humble-bees, which use their old cocoons to hold honey, sometimes adding to them short tubes of wax; and likewise making separate and very irregular rounded cells of wax. At the other end of the series we have the cells of the hive-bee, placed in a double layer: each cell, as is well known, is an hexagonal prism, with the basal edges of its six sides bevelled so as to join an inverted pyramid of three rhombs. These rhombs have certain angles, and the three which form the pyramidal base of a single cell on one side of the comb enter into the composition of the bases of three adjoining cells on the opposite side. In the series between the extreme perfection of the cells of the hive-bee and the simplicity of those of the humble-bee we have the cells of the Mexican *Melipona domestica* carefully described and figured by Pierre Huber. The *Melipona* itself is intermediate in structure between the hive- and humble-bee, but more nearly related to the latter; it forms a nearly regular waxen comb of cylindrical cells, in which the young are hatched, and, in addition, some large cells of wax for holding honey. These latter cells are nearly spherical and of nearly equal sizes, and are aggregated into an irregular mass. But the important point to notice is, that these cells are always made at that degree of nearness to each other that they would have intersected or broken into each other if the spheres had been completed; but this is never permitted, the bees building perfectly flat walls of wax between the spheres which thus tend to intersect. Hence, each cell consists of an outer spherical portion, and of two, three, or more flat surfaces, according as the cell adjoins two, three, or more other cells. When one cell rests on three other cells, which, from the spheres being nearly of the same size, is very frequently and necessarily the case, the three flat surfaces are united into a pyramid; and this pyramid, as Huber has remarked, is manifestly a gross imitation of the three-sided pyramidal base of the cell of the hive-bee. As in the cells of the hive-bee, so here, the three plane surfaces in any one cell necessarily enter into the construction of three adjoining cells. It is obvious that the *Melipona* saves wax, and what is more important, labour, by this manner of building; for the flat walls between the adjoining cells are not double, but are of the same thickness as the outer spherical portions, and yet each flat portion forms a part of two cells.

"Reflecting on this case, it occurred to me that if the *Melipona* had made its spheres at some given distance from each other, and had made them of equal sizes and had arranged them symmetrically in a double layer, the resulting structure would have been as perfect as the comb of the hive-bee. Accordingly I wrote to Professor Miller of Cambridge, and this geometer has kindly read over the following statement, drawn up from his information, and tells me that it is strictly correct:—

"If a number of equal spheres be described with their centres placed in two parallel layers; with the centre of each sphere at the distance of radius $\times \sqrt{2}$, or radius $\times 1.41421$ (or at some lesser distance), from the centres of the six surrounding spheres in the same layer; and at the same distance from the centres of the adjoining spheres in the other and

parallel layer; then, if planes of intersection between the several spheres in both layers be formed, there will result a double layer of hexagonal prisms united together by pyramidal bases formed of three rhombs; and the rhombs and the sides of the hexagonal prisms will have every angle identically the same with the best measurements which have been made of the cells of the hive-bee. But I hear from Prof. Wyman, who has made numerous careful measurements, that the accuracy of the workmanship of the bee has been greatly exaggerated; so much so, that, whatever the typical form of the cell may be, it is rarely, if ever, realised.

"Hence we may safely conclude that, if we could slightly modify the instincts already possessed by the *Melipona*, and in themselves not very wonderful, this bee would make a structure as wonderfully perfect as that of the hive-bee. We must suppose the *Melipona* to have the power of forming her cells truly spherical, and of equal sizes; and this would not be very surprising, seeing that she already does so to a certain extent, and seeing what perfectly cylindrical burrows many insects make in wood, apparently by turning round on a fixed point. We must suppose the *Melipona* to arrange her cells in level layers, as she already does her cylindrical cells; and we must further suppose, and this is the greatest difficulty, that she can somehow judge accurately at what distance to stand from her fellow-labourers when several are making their spheres; but she is already so far enabled to judge of distance that she always describes her spheres so as to intersect to a certain extent, and then she unites the points of intersection by perfectly flat surfaces. By such modifications of instincts which in themselves are not very wonderful—hardly more wonderful than those which guide a bird to make its nest—I believe that the hive-bee has acquired, through natural selection, her inimitable architectural powers.

"But this theory can be tested by experiment. Following the example of Mr. Tegetmeier, I separated two combs and put between them a long, thick, rectangular strip of wax: the bees instantly began to excavate minute circular pits in it; and as they deepened these little pits, they made them wider and wider until they were converted into shallow basins, appearing to the eye perfectly true or parts of a sphere, and of about the diameter of a cell. It was most interesting to observe that wherever several bees had begun to excavate these basins near together, they had begun their work at such a distance from each other, that by the time the basins had acquired the above stated width (*i.e.*, about the width of an ordinary cell), and were in depth about one sixth of the diameter of the sphere of which they formed a part, the rims of the basins intersected or broke into each other. As soon as this occurred, the bees ceased to excavate, and began to build up flat walls of wax on the lines of intersection between the basins, so that each hexagonal prism was built upon the scalloped edge of a smooth basin, instead of on the straight edges of a three-sided pyramid as in the case of ordinary cells.

"I then put into the hive, instead of a thick, rectangular piece of wax, a thin and narrow, knife-edged ridge, coloured with vermilion. The bees instantly began on both sides to excavate little basins near to each other, in the same way as before; but the ridge of wax was so thin, that the bottoms of the basins, if they had been excavated to the same depth as in the former experiment, would have broken into each other from the opposite sides. The bees, however, did not suffer this to happen, and they stopped their excavations in due time; so that the basins, as soon as they had been a little deepened, came to have flat bases; and these flat bases, formed by thin little plates of the vermilion wax left ungnawed, were situated, as far as the eye could judge, exactly along the planes of imaginary intersection between the basins on the opposite sides of the ridge of wax. In some parts, only small portions, in other parts, large portions of a rhombic plate were thus left between the opposed basins, but the work, from the unnatural state of things, had not been neatly performed. The

bees must have worked at very nearly the same rate in circularly gnawing away and deepening the basins on both sides of the ridge of vermilion wax, in order to have thus succeeded in leaving flat plates between the basins, by stopping work at the planes of intersection.

"Considering how flexible thin wax is, I do not see that there is any difficulty in the bees, whilst at work on the two sides of a strip of wax, perceiving when they have gnawed the wax away to the proper thinness, and then stopping their work. In ordinary combs it has appeared to me that the bees do not always succeed in working at exactly the same rate from the opposite sides; for I have noticed half-completed rhombs at the base of a just-commenced cell, which were slightly concave on one side, where I suppose that the bees had excavated too quickly, and convex on the opposite side where the bees had worked less quickly. In one well marked instance, I put the comb back into the hive, and allowed the bees to go on working for a short time, and again examined the cell, and I found that the rhombic plate had been completed, and had become *perfectly flat*: it was absolutely impossible, from the extreme thinness of the little plate, that they could have effected this by gnawing away the convex side; and I suspect that the bees in such cases stand on opposite sides and push and bend the ductile and warm wax (which, as I have tried, is easily done) into its proper intermediate plane, and thus flatten it.

"From the experiment of the ridge of vermilion wax we can see that, if the bees were to build for themselves a thin wall of wax, they could make their cells of the proper shape, by standing at the proper distance from each other, by excavating at the same rate, and by endeavouring to make equal spherical hollows, but never allowing the spheres to break into each other. Now bees, as may be clearly seen by examining the edge of a growing comb, do make a rough, circumferential wall or rim all round the comb; and they gnaw this away from the opposite sides, always working circularly as they deepen each cell. They do not make the whole three-sided pyramidal base of any one cell at the same time, but only that one rhombic plate which stands on the extreme growing margin, or the two plates, as the case may be; and they never complete the upper edges of the rhombic plates, until the hexagonal walls are commenced. Some of these statements differ from those made by the justly celebrated elder Huber, but I am convinced of their accuracy; and if I had space, I could show that they are conformable with my theory.

"Huber's statement, that the very first cell is excavated out of a little parallel-sided wall of wax, is not, as far as I have seen, strictly correct; the first commencement having always been a little hood of wax; but I will not here enter on details. We see how important a part excavation plays in the construction of the cells; but it would be a great error to suppose that the bees cannot build up a rough wall of wax in the proper position—that is, along the plane of intersection between two adjoining spheres. I have several specimens showing clearly that they can do this. Even in the rude circumferential rim or wall of wax round a growing comb, flexures may sometimes be observed, corresponding in position to the planes of the rhombic basal plates of future cells. But the rough wall of wax has in every case to be finished off, by being largely gnawed away on both sides. The manner in which the bees build is curious; they always make the first rough wall from ten to twenty times thicker than the excessively thin finished wall of the cell, which will ultimately be left. We shall understand how they work, by supposing masons first to pile up a broad ridge of cement, and then to begin cutting it away equally on both sides near the ground, till a smooth, very thin wall is left in the middle; the masons always piling up the cut-away cement, and adding fresh cement on the summit of the ridge. We shall thus have a thin wall steadily growing upward, but always crowned by a gigantic coping. From all the cells, both those just commenced and those completed, being thus

crowned by a strong coping of wax, the bees can cluster and crawl over the comb without injuring the delicate hexagonal walls. These walls, as Professor Miller has kindly ascertained for me, vary greatly in thickness; being, on an average of twelve measurements made near the border of the comb, $\frac{1}{352}$ of an inch in thickness; whereas the basal rhomboidal plates are thicker, nearly in the proportion of three to two, having a mean thickness, from twenty-one measurements, of $\frac{1}{229}$ of an inch. By the above singular manner of building, strength is continually given to the comb, with the utmost ultimate economy of wax.

"It seems at first to add to the difficulty of understanding how the cells are made, that a multitude of bees all work together; one bee after working a short time at one cell going to another, so that, as Huber has stated, a score of individuals work even at the commencement of the first cell. I was able practically to show this fact, by covering the edges of the hexagonal walls of a single cell, or the extreme margin of the circumferential rim of growing comb, with an extremely thin layer of melted vermilion wax; and I invariably found that the colour was most delicately diffused by the bees—as delicately as a painter could have done it with his brush—by atoms of the coloured wax having been taken from the spot on which it had been placed, and worked into the growing edges of the cells all round. The work of construction seems to be a sort of balance struck between many bees, all instinctively standing at the same relative distance from each other, all trying to sweep equal spheres, and then building up, or leaving ungnawed, the planes of intersection between these spheres. It was really curious to note in cases of difficulty, as when two pieces of comb met at an angle, how often the bees would pull down and rebuild in different ways the same cell, sometimes recurring to a shape which they had at first rejected.

"When bees have a place on which they can stand in their proper positions for working,—for instance, on a slip of wood, placed directly under the middle of a comb growing downwards, so that the comb has to be built over one face of the slip—in this case the bees can lay the foundations of one wall of a new hexagon, in its strictly proper place, projecting beyond the other completed cells. It suffices that the bees should be enabled to stand at their proper relative distances from each other and from the walls of the last completed cells, and then, by striking imaginary spheres, they can build up a wall intermediate between two adjoining spheres; but, as far as I have seen, they never gnaw away and finish off the angles of a cell till a large part both of that cell and of the adjoining cells has been built. This capacity in bees of laying down under certain circumstances a rough wall in its proper place between two just commenced cells, is important, as it bears on a fact, which seems at first subversive of the foregoing theory; namely, that the cells on the extreme margin of wasp-combs are sometimes strictly hexagonal; but I have not space here to enter on this subject. Nor does there seem to me any great difficulty in a single insect (as in the case of a queen-wasp) making hexagonal cells, if she were to work alternately on the inside and outside of two or three cells commenced at the same time, always standing at the proper relative distance from the parts of the cells just begun, sweeping spheres or cylinders, and building up intermediate planes.

"As natural selection acts only by the accumulation of slight modifications of structure or instinct, each profitable to the individual under its conditions of life, it may reasonably be asked, how a long and graduated succession of modified architectural instincts, all tending towards the present perfect plan of construction, could have profited the progenitors of the hive-bee? I think the answer is not difficult: cells constructed like those of the bee or the wasp gain in strength, and save much in labour and space, and in the materials of which they are constructed. With

respect to the formation of wax, it is known that bees are often hard pressed to get sufficient nectar, and I am informed by Mr. Tegetmeier that it has been experimentally proved that from twelve to fifteen pounds of dry sugar are consumed by a hive of bees for the secretion of a pound of wax; so that a prodigious quantity of fluid nectar must be collected and consumed by the bees in a hive for the secretion of the wax necessary for the construction of their combs. Moreover, many bees have to remain idle for many days during the process of secretion. A large store of honey is indispensable to support a large stock of bees during the winter; and the security of the hive is known mainly to depend on a large number of bees being supported. Hence the saving of wax by largely saving honey, and the time consumed in collecting the honey, must be an important element of success to any family of bees. Of course, the success of the species may be dependent on the number of its enemies, or parasites, or on quite distinct causes, and so be altogether independent of the quantity of honey which the bees can collect. But let us suppose that this latter circumstance determined, as it probably often has determined, whether a bee allied to our humble-bees could exist in large numbers in any country; and let us further suppose that the community lived through the winter, and consequently required a store of honey; there can, in this case, be no doubt that it would be an advantage to our imaginary humble-bee, if a slight modification of her instinct led her to make her waxen cells near together, so as to intersect a little; for a wall in common even to two adjoining cells would save some little labour and wax. Hence it would continually be more and more advantageous to our humble-bees, if they were to make their cells more and more regular, nearer together, and aggregated into a mass, like the cells of the Melipona; for in this case a large part of the bounding surface of each cell would serve to bound the adjoining cells, and much labour and wax would be saved. Again, from the same cause, it would be advantageous to the Melipona, if she were to make her cells closer together, and more regular in every way than at present; for then, as we have seen, the spherical surfaces would wholly disappear and be replaced by plane surfaces; and the Melipona would make a comb as perfect as that of the hive-bee. Beyond this stage of perfection in architecture, natural selection could not lead; for the comb of the hive-bee, as far as we can see, is absolutely perfect in economising labour and wax.

"Thus, as I believe, the most wonderful of all known instincts, that of the hive-bee, can be explained by natural selection having taken advantage of numerous, successive, slight modifications of simpler instincts, natural selection having, by slow degrees, more and more perfectly led the bees to sweep equal spheres at a given distance from each other in a double layer, and to build up and excavate the wax along the planes of intersection; the bees, of course, no more knowing that they swept their spheres at one particular distance from each other, than they know what are the several angles of the hexagonal prisms and of the basal rhombic plates; the motive power of the process of natural selection having been the construction of cells of due strength and of the proper size and shape for the larvæ, this being effected with the greatest possible economy of labour and wax; that individual swarm which thus made the best cells with least labour, and least waste of honey in the secretion of wax, having succeeded best, and having transmitted their newly acquired economical instincts to new swarms, which in their turn will have had the best chance of succeeding in the struggle for existence." (*The Origin of Species*, final edition, chapter 8.)

SECTION XXIII.—GENERALISATION.

CONCLUSION 25.

Need of Strenuous Mental Application in the Process of Generalisation, and need of the Generalisations being Graded, Comprehensive, Important, Numerous, Full, Rational and Relevant, Original, Automatically Initiated, and Methodically Developed.

§ 163. Guided by Conclusion 20, we examine (1) the preliminaries (Conclusions 1–13); we begin then (2) to determine as precisely as possible the nature of the problem to be investigated (Conclusions 14–15); and (3) commence our observations (Conclusions 16–24). Having accomplished this, we embark on the process of (4) generalisation. Just as we cautiously pass from *this* fact as apprehended at *this* moment to *the* fact, so we pass from *the* fact to the *class* which comprehends all most closely resembling facts, and thence to remoter resemblances and more extensive classes. By fact we mean, of course, any and every kind of static and dynamic fact—physical, vital, and cultural.

§ 164. (a) *INTENSE CONCENTRATION*.—In generalising, as in observing and deducing, we need intently and continuously to concentrate all our faculties and to shun both over-confidence and over-anxiety. (See § 154.)

§ 165. (b) *GRADED GENERALISATIONS*.—The principles of prudence applied to observation equally apply to what is ordinarily termed generalisation. *The formation of large generalisations based on slender data is hence as unjustifiable as statements concerning individual facts based on scanty evidence.* Generalisations should be therefore graded, and investigators should cautiously feel their way from class to class, seeing that many generations of thinkers are frequently required for developing a truly comprehensive and sound generalisation, as is illustrated, for instance, by the evolution of astronomical theory from Ptolemy to Copernicus and from Copernicus to Laplace. In generalising, then, we should gradually pass from closer to remoter resemblances, as from the falling of heavier substances to the falling of lighter substances, to the falling of the moon and the earth, and thence, progressively, to the framing of the universal law of gravitation, forming in this manner ever more extensive classes of facts. “The safest course, when it can be followed, is to rise by inductions carried on among laws, as among facts, from law to law; perceiving, as we go on, how laws which we have looked upon as unconnected become particular cases, either one of the other, or all of one still more general, and, at length, blend altogether in the point of view from which we learn to regard them.” (Sir John Herschel, *Discourse*, [217].)

Where, as in the example which follows, the more general facts are established, it is of incalculable advantage to rise from

law to law until we reach the pinnacle. Frequently, however, the facts are represented by a heterogeneous mass which can only be slowly reduced to order and understood. In such instances we pursue our researches until some slight semblance of order is created in part of the mass, and we finally resolve on exploring as exhaustively as practicable one or another direction suggested by the preliminary conclusions reached. Here, obviously, there can be no rising from law to law, since the value, or even the correctness, of the conclusions reached is undetermined, since our most heroic endeavours will probably yield only modest fruits, and since the discovery of a comprehensive law is, in the circumstances, a counsel of perfection. For this reason we relegate the grading of generalisations to the conclusion of the enquiry, and are content that our most comprehensive generalisation should be a comparatively restricted one. Accordingly, the scientific pioneer must toilsomely wrest truths from nature wherever he can, without being truly cognisant of their value, whereas, with the advance of science, it becomes gradually easier to take advantage of established classifications and proceed at a perceptible pace in a forward or upward direction. To rise from law to law is therefore only practicable when we are already familiar with many verified generalisations.

It will be well to define as precisely as possible the process of graded generalising. Finding, for example, that consequent on the application of pressure some hydrogen gas occupies less space, I carefully ascertain the relation of pressure to density in the sample at different times, and think I perceive that its density is directly proportional to the pressure to which it is subjected, that is, if the pressure be doubled, its volume is halved, and when the pressure is halved, its volume is doubled. I formulate then, after sundry experiments, the hypothesis that hydrogen always behaves in this manner; but ascertain, on closer investigation, that allowance needs to be made for temperature, very high pressure, and so forth. This we might term a *simple generalisation*: reasoning from a given fact at a given time to the class to which it appertains.

I advance now a step further. I experiment whether the gas nearest to hydrogen in specific gravity reacts in a similar way to pressure and removal of pressure, and observe identity of effect. I inspect then a few samples of gases of greater and greater specific gravity, and tentatively conclude that the volume of a sample of any gas normally varies inversely with the pressure thereon. I test this conclusion repeatedly, applying it perhaps to every gas I can procure, studious of including the largest variety of gases, and recording the conditions under which I obtain the results. I feel now warranted in converting the simple generalisation into a *compound generalisation*, and assert that the volume of any gas varies inversely with the amount of pressure to which it is subjected. (Boyle's law.)

It was natural to extend from (1) a sample of hydrogen at a particular time to (2) that same sample at other times; from this again to (3) other samples and (4) to the particular gas in general. It was equally natural to extend the observation to (5) some other gases less and less closely related to hydrogen, and then (6) to all gases. Now since there are three states of matter—gaseous, liquid, and solid (including viscous), it is also feasible to extend the generalisation tentatively to (7) some liquid, then (8) to more liquids, thence (9) to all liquids, and supposing that we ascertained that Boyle's law held good of all liquids, we might, finally, extend the conclusion to (10) the lightest solid body, (11) to a number of solid bodies more and more heavy, and (12) to all solid bodies. I should then, granting that the above-mentioned law also held good of all solids, state the most general and universal law, namely, that the volume of any given substance at any given temperature is inversely proportional to the pressure to which it is subjected. This we might name a *universal generalisation*.

However, as a matter of fact, Boyle's law¹ applies neither to liquids nor to solids, and therefore we should be compelled to rest content with the more restricted compass of our generalisation, and even be obliged to allow for deviations assumed to be due to the attraction of the molecules for each other and to the volume occupied by the molecules.² Of course, had the question been the problem of the indestructibility or the gravitational force of matter, we should have been in a position to extend the first intimation derived from the study of the sample of one body which proved indestructible or affected the scales, to all matter—gaseous, liquid, and solid.

However, as in the science which deals with religious phenomena, and in other new and intricate sciences, trustworthy classifications may as yet not exist. In such an instance they have to be created, and here the obstacles in the way of generalising may be most formidable. Or, what may be as bad nearly, classifications may exist in abundance, as in proverbs or in astrology, and these classifications may be unscientific and misleading. In such circumstances the whole ground has to be mapped out afresh, and the investigator needs to make accurate studies of groups of facts, alertly seeking for significant data and for multitudes of conclusions which should by degrees enable him to formulate a classificatory scheme.

¹ "Boyle himself only proved his law in the case of atmospheric air; but the observation was subsequently (1676) generalised by Marriotte." (Thorpe, *op. cit.*, vol. 1, p. 139.)

² "Bodies which can support a longitudinal pressure however small, without being supported by a lateral pressure, are called solids. A liquid differs essentially from a solid in being destitute of the power of sustaining pressure unless it is supported laterally in every direction. The distinguishing feature of a gas is that of indefinite expansion." (A. H. Hiorns, *Principles of Metallurgy*, 1914, p. 8.)

§ 166. (c) *COMPREHENSIVE GENERALISATIONS.*—The desire to understand the world turns men away from particular facts, for they feel that the number of these is so multitudinous that it is humanly impossible to collect, remember, or understand them. Unfortunately, men have not advanced a short distance beyond and insisted that *trifling generalisations are scarcely distinguishable from particular facts*, and that a vast array of unconnected generalisations and relations tends to confuse rather than to enlighten. Countless modern experiments, and especially observations connected with the mental and social sciences, illustrate this inference. For the future, therefore, all narrow generalisations which are not intended to fit into a larger scheme already formulated, should be esteemed as trivial and suspect, unless it is quite impracticable to reach extended generalisations. *Probably the greatness of great men has mainly consisted in doing what the average of investigators would also have effected if it were generally recognised that the purpose of a scientific enquiry is to reach sweeping generalisations.*¹ Not only, therefore, are graded generalisations necessary, but the constant endeavour should be to attain to the broadest possible generalisations, and this has become increasingly possible through the accumulation of scientific facts and conclusions. If this be conceded, it follows that the present practice, of individuals engaging in a large number of relatively restricted and unconnected investigations requiring no wide outlook, should be replaced, now that science is sufficiently advanced to permit this, by their undertaking, as a rule, one or two investigations covering extensive ground and occupying them for practically a life-time.²

If it were merely a question of piecing together a great number of petty generalisations into an imposing mosaic, no

¹ "Then, and then only, may we hope well of the sciences, when in a just scale of ascent, and by successive steps not interrupted or broken, we rise from particulars to lesser axioms; and then to middle axioms, one above the other; and last of all to the most general." (Bacon, *Novum Organum*, bk. 1, 104.) It is not improbable that training would transform all investigators into expert generalisers.

² "A. Comte signalait déjà les inconvénients de la division du travail dans l'ordre intellectuel. La spécialisation à outrance dans le domaine scientifique fait perdre au savant l'habitude de la généralisation; en se cantonnant dans sa petite sphère, il est privé de tout contact avec les autres sphères qui lui deviennent de plus en plus étrangères. Sans doute il augmentera plus facilement, dans sa sphère, le nombre des connaissances précises. Mais la science ne progresse pas seulement par l'accumulation des petites découvertes éparses; c'est aussi et surtout à la coordination, à la synthèse de toutes ces vérités isolées qu'il importe d'apporter ses efforts; la science risque de s'émietter en une multitude de petites spécialités si elle manque d'architectes, de têtes encyclopédiques, d'esprits synthétiques pour rassembler, pour coordonner les connaissances innombrables que les ouvriers de la pensée ont accumulées de toutes parts." (Paul Caillet, *op. cit.*, p. 299.) The contrast between the architects and the labourers seems a little strained, since in science either the architects are simultaneously labourers and the labourers architects or their work is of questionable value.

harm would ensue; but almost invariably daylight only emerges when we have proceeded far in an investigation, and accordingly fractional generalisations, more often than not, are largely erroneous, and cannot be profitably combined. It is of decided consequence, therefore, that the investigator should not relax his efforts until he has virtually reached the heart of his subject, which is but reaffirming our suggestion that men and women should devote virtually a life-time to solving one problem to some extent. In view of the confusion, and even apathy and antipathy, arising from the publication of a long series of disjointed, necessarily crude, gravely misleading, and often contradictory essays, there would be an enormous saving of time and effort if concentration of interest and activity on a large scale became universal in science. From another direction, then, we reach the conclusion that the watchword for all investigators needs to be to aim at comprehensive generalisations.

In matters of practice the above is admirably illustrated by two parallel lines of enquiry conducted during the last generation. On the one hand, psychologists and physiologists have published a considerable number of monographs bearing on industrial efficiency and increased productivity, and relating to such subjects as expenditure of human energy, fatigue, and the like. The practical effect of these isolated and exceedingly limited efforts has been virtually negligible. On the other hand, efficientists in America, imperfectly equipped scientifically, decomposed certain industrial processes into their elements and recomposed them on strictly economic lines, *taking account of all noteworthy accompanying circumstances*. Their interest lay in the totality of the process, and their practical success was almost instantaneous and far-reaching. The very comprehensiveness of their enterprise saved them from innumerable fallacies and removed countless complexities.

Whilst extremely wide, but unexplained, generalisations frequently convey little meaning to the student, and are therefore of small value,¹ it is of material importance in actual scientific work to posit them sometimes in order to be clear as to the final goal.

Thus, suppose we observe that comparatively hot water issuing in a thin and weak stream from a tap feels relatively tepid to the hand placed immediately underneath. Noting the principle implied, we may then, without graded generalising,

¹ "Bacon has judiciously observed that the *axiomata media* of every science principally constitute its value. The lowest generalisations, until explained by and resolved into the middle principles of which they are the consequences, have only the imperfect accuracy of empirical laws; while the most general laws are *too* general, and include too few circumstances, to give sufficient indication of what happens in individual cases where the circumstances are almost always immensely numerous." (Mill, *Logic*, bk. 6, ch. 5, § 5.)

strive to express the fact in the most comprehensive formula for the specific purpose mentioned. This would be perhaps "Wherever matters of degree (more generally stated, wherever relations) are involved, there the influence of the degree (or relation) should be allowed for or examined". Valuable as such a generalisation may be for directive and future needs, its bare statement would probably not elucidate or illuminate the problem we strive to grasp. It would, however, compel us to continue generalising our experience and our tentative extensions until the relevant limit to the enquiry is reached. For instance, we should begin by fixing on the conspicuous fact that the thinner or thicker the cylindrical stream of hot water, the less or more shall we feel as hot the water falling on the hand. We should, of course, provisionally and slowly generalise the word *hand* to any part of the body and to any object, the word *water* to any substance, the word *hot* to any temperature and to all the senses and all forces, until we reached the most comprehensive generalisation.

Or, noting that a shadow is explained as a merely privative fact—the relative absence of illumination in a relatively lighted locality—we grope and find the widest term Obstruction under which it can be profitably subsumed. We may then state "Everywhere allow for partial or complete obstruction as a possible explanation of a phenomenon". Here we meet with a much obscurer statement than the preceding one—one which, unexpanded, suggests both too little and too much.

Or, consider the case of the notice-board analysed in § 87, where the most comprehensive statement arrived at is virtually: "Make a statement wherever advisable". Exceedingly helpful as such a proposition might be for the specific object of guidance in the active process of generalising, its bare mention might be merely irritating or amusing, though a concrete analysis of the variety of statements, places, and circumstances methodically exploited might lead us back to reality. Conceding, however, that extremely comprehensive statements may be sometimes also luminous or may be concerned with a subject many details of which are well known, such statements would prove useful both for generalising and deductive ends. Indeed, with the progress of knowledge, statements of this character will become more and more intelligible and therefore more and more valuable *per se*. They would constitute the most general laws of nature and of life.

A scientific methodology would make the search for large generalisations an invariable attribute of the scientific worker; unfortunately even among the vanguard of scientific thinkers there is often a general lack of the habit of comprehensive generalising. Why should not Sadi Carnot have definitely proposed the law of the conservation of energy? Why should not the discovery of the nature of itch have been forthwith

generalised to the furthest limits by learned physicians? Why should so many generalisations have been so slowly evolved, and why should they have so frequently met with prolonged and stubborn opposition? Indeed, why should not many extensive generalisations have suggested themselves earlier and to more individuals? It is, of course, a familiar fact that in certain cases an extraordinary accident led to a step in advance, and, in addition, that it is not infrequently true that full or even partial verification is difficult. Yet if men were trained to generalise by habit and methodically, it is not easy to resist the conclusion that the progress of science would be materially accelerated, and that whilst fragmentary and slipshod generalisations would greatly diminish, comprehensive and defensible generalisations would not only be proposed in abundance, but be universally welcomed and impartially examined. The remarkable fact that large and valid generalisations have been frequently arrived at by young scholars or by those who were not academic teachers, argues, from this point of view, that numerous young scholars and laymen do not permit themselves to be imposed upon so readily by tradition as many of those who have become professed and professional teachers. Experts and bureaucrats as a body are noted for their disastrous love of routine, and science also to a certain extent suffers from its protagonists not seldom sinking unnecessarily into deep ruts.

§ 167. (d) *IMPORTANT GENERALISATIONS*.—Sweeping generalisations should also aim at being of the highest import scientifically. They should, if possible, establish some general fact which throws directly much light on a far-reaching question and leads to countless important deductions and practical applications. Merely for the sake of illustration we may mention such widely appreciated problems for individual or collective solution as the evolution of (a) the earth, (b) the solar system, and (c) our universe; the fundamental laws and relations of heat, light, electricity, magnetism, radiation, and chemical affinity; the nature, connection, and development of (a) the chemical elements and compounds and (b) crystals; the constitution and dynamics of the living cell, and the genesis of life; the causes of irritability, adaptation, growth, reproduction, senescence, death, heredity, variation, and evolution in living beings; the evolution of sensibility, the senses, of instincts, and of the intelligence; the interaction and interrelations of cells, tissues, organs, systems of organs, organisms, and neighbouring groups of organisms; the possible unity, or exact relations, of mind and matter; the distinctive characteristics of man and of his immediate ancestry, and their explanation; the nature, origin, and further development of (a) language, of (b) the arts, of (c) economic processes, and of (d) the primary social institutions; the foundations and precepts of (a) morality and (b) æsthetics, and the effectual cultivation among human beings

generally of a love of the good and the beautiful; (a) the determination of a hygienic mode of living, and (b) the eradication of infectious diseases in children, adults, domestic animals, and cultivated plants; the scientific exploitation of agriculture and of the products of the soil generally; the placing of industry, commerce, and home management, and the processes involved in them, on a strictly scientific basis; the conservation of natural utilities and beauties; the relatively inexpensive supply of an abundance of energy and its virtually complete and useful absorption; the full ascertainment and control of meteorological conditions on land, sea, and air; the causes and the prevention of poverty; the re-organisation of (a) communities and states and (b) governance on a truly democratic foundation; the scientific basis, end, and methods of home, school, and vocational education, and the effective training of teachers; the averting of (a) floods, (b) conflagrations, (c) storms (especially at sea), (d) volcanic outbreaks, and (e) earthquakes; and, generally, the systematic application of the sciences to the arts, of the arts to the sciences, and of both to life and men's highest aspirations. If many of the tasks, or part tasks, here proposed are naturally far too ambitious for the life-work of a solitary individual, there is added reason why there should be extensive collaboration, to the extent even of companies of scholars concerted, or well-equipped national or international institutions, concentrating on a problem (see Conclusion 12); and if, because of inherent difficulties, partial success alone is obtainable, the ideal of aiming, as a rule, at the establishment of momentous general facts is none the less worthy of adoption.

Oh, if we draw a circle premature,
Heedless of far gain,
Greedy for quick returns of profit, sure
Bad is our bargain!

(Browning, *A Grammarian's Funeral*)

On the practical side our age is already keenly alive to the need of bold conceptions. One of the demands is for the production at the pits' mouth of sufficient electricity to satisfy the industrial and domestic requirements of the whole country. Apart from the patent economic advantages of this scheme, the change would mean the break-up of the ugly centres grouped around the coal districts, the even scattering of industrial activity to every part of the land, and the laying of the horrid smoke-fiend. With the same general end in view of organising and developing the power supply on a nation-wide basis, vast hydrographic surveys are being undertaken, which will, at least in certain countries, end in radically transforming the face of industry by making it dependent on hydro-electricity and independent of foreign fuel or of coal-mining. So, too, there is every prospect of motor-road traffic, preceded by roadbuilding on a stupendous scale, becoming a serious

rival to railways and rendering equally accessible every part of every country. Similarly, the prevention of energy waste, the irrigation of the land (more particularly in tropical countries), the successful combating of insect and germ pests, the scientific re-organisation of the industrial and commercial life, and the development of wireless telegraphy and telephony, will soon grow into problems grappled with by mighty national and international endeavours. In fact, we may look forward to a time when numerous problems of every type affecting countries as a whole will be dealt with nationally and with the required breadth of outlook. The World War began universally by the declaration of a national moratorium which saved the financial systems of the countries involved from collapsing, and was carried on by every country with such comparatively great success because of the bold statesmanship exhibited in dealing with internal problems of a colossal magnitude.

§ 168. (e) *NUMEROUS GENERALISATIONS*.—It is a universal temptation in the personal affairs of life, in the various social problems, in the biological and even the physical sciences, to think that a particular truth which we have found, or deem that we have found, explains everything or will set everything right. Much of the existing conservatism and fanaticism is due to the exaggerated value placed on a particular truth, the tacit assumption being that if something interprets or promotes anything, it must interpret and promote everything in its peculiar sphere, say in education, politics, or jurisprudence. On the contrary, not every important generalisation is *de facto* a comprehensive, let alone an all-comprehensive, generalisation, and until a generalisation is indisputably established as all-embracing, we should definitely and consciously assume that many particular truths, rather than one of this class, explain a group of facts or vitally promote an object.

For instance, the author might have regarded the process of generalising as the only one of moment in methodology, or he might have assumed that a methodology comprehending observation, generalisation, and deduction, exhausted the subject. However, numerous as are his main divisions, it is eminently probable that criticism would reveal not a few unanticipated divisions. The fact is that an ideal methodology is as yet impossible, and that we need therefore not only aim at reaching the most comprehensive and ideally most simple generalisations, but compromise and be ready to attain to numerous, somewhat complicated and imperfectly connected facts and generalisations. Indeed, the final methodological ideal is fully as useful and fully as unreal as that of the geometrician.

§ 169. (f) *FULL GENERALISATIONS*.—A generalisation, to be of serious import, should be full, as well as wide and important. To assert, for instance, that gravitation or terrestrial attraction explains the phenomenon of weight, that electricity

and magnetism are one, or that man is primarily adapted for the specio-culturally determined life, is to state almost nothing, if no more be stated. And this is manifest in minor matters. To generalise, for example, the assertion "Consult Baedeker in regard to Florence", to "Consult always something when in doubt", is practically a waste of mental force, unless we definitely expand the assertion into something like this (somewhat exaggerated) form: "Consult libraries, newspaper reading rooms, dictionaries, encyclopedias, atlases, charts, text-books, books of statistics, year-books, guide-books, address-books, books generally (prefaces, contents, summaries, conclusions, and indexes), bibliographies, catalogues, lists, museums, galleries, zoological and botanical gardens, information bureaus, societies or persons interested in the matter under consideration, guides, experts, etc., etc.; and, in fact, consult whenever in doubt".

Similarly, if in our lengthy section relating to observation, we had only dilated on the general virtue of observation and had offered a miscellany of haphazard illustrations, we should have fallen wide of the scientific mark. The real and far-reaching value of observation is created by the many rules which control the process: to observe exhaustively, minutely, etc., etc. Else we have observations which are likely to prove worthless. Fulness is of the essence here. Fulness in a generalisation, the provision of a number of particulars, should be therefore habitually aimed at, for fulness alone endows it with meaning and significance, forming as it also does the necessary stimulus and point of departure for deductive reasoning. Darwin's *Origin of Species* and Newton's *Principia*, or, even better still, Aristotle's works, present illustrations of what is signified by fulness in detail.

§ 170. (g) RATIONAL AND RELEVANT GENERALISATIONS.—Generalisations should, moreover, be rational. An enquiry is commonly undertaken for the purpose of elucidating a particular subject matter. In attempting this there may be, and should be, fulness of statements and of conclusions to a certain degree; but if absolute fulness be the goal, the enquiry degenerates into a general investigation having no special end in view. To prove exhaustively that man is fitted for the specio-culturally determined state, and to draw up some of the principal implications, is right and proper; but to endeavour, having regard to the peculiar subject of the enquiry, to render explicit all that is implicit, and to pursue each of the implications into the minutest particularity, that is, to write a complete science of culture, including all the connected sciences, would be irrational. Enquiries differ, of course, in intension and extension, and an exhaustive enquiry will comprise much; yet he who in connection with an investigation relating to the nature of protoplasm, would write a compendium of astronomy, physics, botany, and zoology, would act contrary to science and to modern common

sense. His office is to adduce as large an array as possible of salient facts and factors bearing on his special problem, and, beyond this, to indulge in incidental excursions only.

§ 171. (h) ORIGINAL GENERALISATIONS.—Provided generalisations are at least in some measure original, they fall outside the purview of science, unless, indeed, they serve the important purpose of testing a theory. In fact, the more strikingly novel an enquiry, the more valuable is it likely to prove.

Here are some rules relating to the cultivation of originality. These should be supplemented by the methodological aids mentioned in connection with the promotion of economy (Conclusion 10), accuracy (§ 124), resourcefulness (§ 135), and self-training (§ 86):—

In a given direction improvements, discoveries, and inventions may be effected (pre-supposing thorough training, long practice, and full up-to-date information) by (1) our striving to become conscious of, or/and directing attention to, *e.g.*, disadvantages, defects, deficiencies, absence of standardised methods and products, errors, confusions, unnecessary complexity and wastefulness, or series of facts and activities not inherently correlated or connected or not subsumed under a general or universal law, and discrepancies between the real and men's ideal (economic, moral, intellectual, hygienic, and æsthetic), be these generally admitted, easily noticed, accidentally discovered, or perceptible on deliberate and systematic individual and collective examination; then (2) inquiring where such and/or cognate improvements, inventions, and discoveries already exist, and applying or adapting them, and developing them to the furthest; and, where (2) is inadequate, (3) ascertaining with meticulous care the precise defects, etc., the general principles in removing such, and the known or likely methods which are applied or applicable in connection with these principles, and proceeding or inducing others to proceed, accordingly; furthermore, by (4) examining the degree of each quality and its relations, applying the dialectical Conclusions 27 and 28, and examining closely or remotely related facts or activities akin in some respect, with a view to conceivable or practicable improvements, inventions, and discoveries; (5) fully profiting by ideas due to careful classification, to accident, to special and exceptional circumstances, and to novel or apparently insignificant facts, inventions, and discoveries; (6) applying the methods of systematic examination, generalisation, deduction, and application; and (7) seeking to invent or discover by the above methods new or additional ways of satisfying given wants or creating others of a desirable character.

Defects and imperfections should be in this manner brought to the focus of consciousness and systematically dealt with. The noiseless typewriter is a recent instance of the application of this method; stainless steel is another.

§ 172. (i) AUTOMATICALLY INITIATED AND METHODICALLY DEVELOPED GENERALISATIONS.—In Section XIII it was shown that we cannot with advantage generalise every statement; but this should not deter us from habitually generalising, since we may be sure that, whilst we should thus make many misses, we shall also make many unforeseen hits. Wherever, for instance, we reach some conclusion regarding a single fact, several facts, or a class of facts, we may with profit attempt to generalise these at least to related facts or classes

of facts, and, if we have been successful, we may extend the generalisation in every direction so far as circumstances permit. Thus Kopp, examining the specific gravity of liquids at their boiling point, not only detected regularities among their specific volumes, but also in the boiling points of related substances, the temperature of ebullition, and the character of the compounds; to-day the fact that uranium and radium change into other elements, has suggested the subtle question whether all elements are in process of decomposition and whether this is also true of compounds; the explanation of the inertia of electricity has suggested that somehow the inertia of matter might have the same cause, that indeed matter may be composed of electrons; and the fixation of nitrogen by bacteria, may suggest that various other useful substances are fixed by them, as water in an arid climate, and that all such bacteria may be artificially multiplied. The present custom is to generalise when something accidentally suggests this course to be desirable. We ought, however, to make it a *habit* to generalise. It may be that we shall thus reach only a second or a third fact, or one class, or, on the other hand, a very comprehensive generalisation: it does not matter, so long as we have exhausted the possibilities. Such a habit will develop our powers of generalising and avoid our neglecting to generalise when we ought to do so, and it will also prevent our reasoning to a second fact alone or only to the nearest class. This process presupposes substantially original, definite, and scientifically arrived at statements respecting facts or classes; because, to attempt to generalise, for example, every statement in every article or book which crosses our path, would be folly and would lead to disgust of generalising. It also assumes habitual resort to verification, without which the process proposed is destitute of sense and value.

We may now offer a few illustrations in regard to methodical procedure. In connection with a series of particulars relating to the senses, I deliberately seek for something to generalise. Noting a reference to the relative rapidity of one sense, I determine to discover rapidity of apprehension in all the senses. After this, I methodically arrive at the term Time, the most comprehensive class to which rapidity belongs, and decide to render definite all the propositions so far as they relate to Time. Continuing the process of extension, I pass from Time to the other aspects named in our second part of the table of Primary Categories, and successively endeavour to utilise these. The limit of extension is then reached regarding the problem which we set out to examine. Again, I observe in my notes that some sense is assisted by some other sense. I amplify this into the question: "How far is each of the senses assisted by each of the other senses?" And, after studying this question with a view to extending it to the furthest bounds, I obtain,

by applying Conclusion 28, the query: "How far is each sense and any group of senses assisted, not assisted, never assisted, impeded, etc., by each sense and any group of senses, and by movement, impulse, feeling, mood, habit, memory, imagination, ratiocination, will, etc.?" Similarly, noticing the term *biomechanics*, I extend to all the divisions of physics; then, backward, apply all biological divisions to physics; then, forward again, from physics and biology to specio-psychics; and, lastly, all the sub-divisions of the above to all the sub-divisions of the above, in the most methodical manner practicable. (See Conclusion 33, Scheme of Classification.) In generalising in this manner, it should not be excessively difficult to reach an appreciable number of useful and sometimes invaluable minor and major statements. Yet it ought to be borne in mind that such methodical generalising, if it is to proceed far, is only of real utility after we have ascertained a prodigious variety of uniformities. Else we are pumping mud, and are sacrificing considerably more time in futile verification than we should have spent in independent observation.

Once more. When examining a series of conclusions at which we have arrived, we endeavour to note in what profitable order they may be arranged. The suggestion is, perhaps, that a forward, lateral, or some other order is most appropriate. As we inspect the conclusions in the order which apparently most nearly fits them, we observe, however, applying Conclusion 27, that various links are missing. We, accordingly, complete the chain by detecting and inserting the missing links. Mendelyeff's periodic law is a prominent exemplification of this method, and a kindred one would be the proper classification of the sciences. (See Conclusion 33.) However, the problem here discussed is not only one of completing a system. It may be a question of proportion. There may be a too large or too small, a too much or too little, a too this or too that. We then prune or graft until there is a practically balanced or complete result before us. The multitude of existing classifications may be utilised as auxiliaries, as well as the special classifications which have presented themselves during the enquiry. Finally, when several items have been collected, we endeavour not only to arrange them in a certain order, but to connect them, and, if possible, to marshal them as parts of a single organised totality.

Or examine the problem of the elaboration of a rule of life. Noting in the preliminary investigation that sundry fundamental psychic qualities are comprised in the provisional rule, I strive to complete these. Theoretically this means that we should act with our whole mental nature, our whole mental nature being defined in conformity with the text-books of psychology as constituted of: the intelligence (interpreted as mainly memory, imagination, reasoning, and judgment); the feelings (consisting,

on the side of the sentiments, of the sense of right or conscience, of sympathy or fellow-feeling, refinement or tact, and of humour or geniality); and the will (interpreted as mainly initiative, resoluteness, perseverance, and strenuousness). The rule then reads: "In your conduct (and, further generalising methodically, in all your activities!) utilise all the powers of the mind, *i.e.*, carry out promptly and intelligently, in a sympathetic, genial, and tactful manner, what a thoroughly enlightened and awakened conscience (reason, taste, etc.) demands." We arrive in this methodical way at a complete rule, so far as our present knowledge extends.

Methodical procedure is of cardinal importance from the commencement of an enquiry; but it should not be severely pressed until we have made considerable headway and until we are tolerably sure of our ground. For example, assuming any two points reached, we search for any possible points disregarded between or beyond the two points, and, having reached some kind of scheme, we proceed to eliminate what is irrelevant and add what is lacking. Even to the last, however, the system constructed needs to be critically re-examined, and, if required, recast, for especially towards the end of an enquiry should gaps and flaws become visible or even glaring. (Conclusion 30.) So, too, the amount of time we have devoted to a certain portion of our investigation or the amount of material we have collected, will each, when examined, perhaps suggest that adequate attention has not been paid to that portion, or that the material collected or the time absorbed is more than ample. And we shall not rest satisfied till we have done what is necessary to weld all the details into a connected whole, or, at the very least, to link them, so far as permissible, in a particular order. Unintermittently, therefore, we need to aim at rounded or strictly serial and connected results, and arrange that continuity and proportion are throughout respected. So long as this object is not attained, our work is manifestly incomplete, and to obviate such incompleteness we should have recourse to methodological procedure.

From the foregoing it is evident that the value of proceeding methodically cannot be overrated. Leaving matters to chance or to half-chance, we not only progress with painful slowness, but we can never be confident in our conclusions. On the contrary, by methodical observation, recollection, generalising, deducing, application, and classifying, we advance with rapid strides and safely. The collection of facts will proceed with great rapidity, and the explanation of these facts will be consummated at the earliest possible moment, when methodological canons continuously govern the process of enquiry. Darwin never merely indulged in assertions, nor merely speculated; but he systematically applied logical rules throughout all his work. One might, indeed, claim that the *truest token of intellec-*

tual and other progress is progress in method, for the sufficient reason that method, if socially available, places us in a position to fix and multiply facts for the benefit of our contemporaries and descendants. In its absence, we inherit the outcome of others' labour, but remain ignorant of any valuable methods they may have applied, and continue therefore very much in the condition of Sisyphus. In the case of secret processes this disadvantage is self-evident, inasmuch as the secret is sometimes interred with its custodian.

From the viewpoint of methodical procedure, granting the existence of a general methodology, the first step is to classify facts and processes, and to effect this in the manner above indicated. (See also Conclusion 3.) Where in any science or art a passable store of these classifications exists, the inquirer is immensely aided, and is in turn able to improve them. So far as methodical procedure in classification is concerned, it consists in organically stringing together the facts under review at any time. Wherever there are contrasts and opposites (as good and bad, or long and short), the one should automatically suggest the other, all that lies between the termini, and all related divisions to the furthest limit. Degree-extremes, such as pool to ocean, infancy to senility, or ingestion to excretion, should be at once detected and methodically treated as ordinary contrasts. Also, each alleged division needs to be examined as to its homogeneity (as a given colour), and as to how far the division between it and other supposed divisions may be bridged (as deliberation and habit). Relations of quantity, time, space, consciousness, degree, state, change, and personal equation, noted in the second part of the table of Primary Categories, should be methodically exhausted; as well as the processes enumerated in the third part of the above table.

Another illustration. In connection with an international movement of a humanitarian character, I contemplate writing to a certain Speaker. I generalise this to all Speakers, to all Prime Ministers and Foreign Secretaries, to all Cabinet Ministers, to all Party Leaders, to all Ambassadors and Consuls-General, to all Rulers, to all Presidents of international associations, to all Principals of universities, to all notable thinkers, and so on; and I further generalise by mentally resolving to employ this generalisation and improve or adapt it in any appropriate future contingency. I press beyond to national and local activities, and then to other spheres of an international, national, local, group, individual, and incidental (also physical, intellectual, moral, æsthetic, and vocational) character. Or, watching close by the performance of a first-rate pianist, I reason that his extreme delicacy and enormous vigour of touch could be deliberately imparted to ordinary pupils; that these qualities should mark the musician generally, also the painter, the sculptor, the architect, including the arts and crafts generally; that they might

be applied to poetry, literature, and oratory; and that they are, perhaps, in place in all human activities.

Again. Suppose it is contended that nationalism is of supreme importance because of its alleged distinctiveness and matchless cultural value.¹ At once, automatically, we form as complete a classification as we can of the relevant facts—individual, common interests of individuals (religion, municipal and political parties, art, science, economics, health), family, neighbourhood, city, district, county, province, country, empire, pan(Slavs, Germans), religion, pan(Islamites), race, internationalism, cosmopolitanism, humanity, life, nature—and then ask ourselves how far each of these is distinctive and possesses cultural value. Our conclusion will evidently be that justice should be done to all component parts of mankind, that several of these are extremely important, and that it is deceptive, and even perilous, to select one of them for general emphasis save in a limited problem. That is, a methodical arrangement of the whole series of pertinent facts within which nationalism falls, enables us forthwith to correct a plausible and menacing error.

So, too, noting that a law term is appropriately applied outside the arena of law, this observation is, subject to convenience, methodically generalised according to the cultural list of categories in § 1, to all terms of law, and, thence, progressively, to all classes of terms having a restricted signification; or remarking that an appellative term is by some writer narrowed in meaning, the process is methodically applied to all such classes of terms, and, inversely, to the methodical generalisation of restricted terms. Such a course should also suggest the figurative use of concrete terms and proper names, and the thorough exhaustion of the favourable possibilities of language along all lines.

Assume, lastly, that I am struck with the variations in the prefix *con*. Instead of examining these at haphazard, as suggested by a capricious memory, I prepare the methodical statement which follows:—

Co - agulation
Co m bination
Co n ceal
Co n dition
Co - education
Co n firm
Co n gress
Co - hesion
Co - incident
Co n junction
Co k
Co l lection

¹ Regionalists, not without some excellent reasons, frequently advance the same claim to-day. It is by admitting the great importance of the bulk of the theories which emphasise one or another aspect of life, that we shall most effectually promote the progress of the world.

Co m mence
 Co n nection
 Co - operation
 Com plexion
 Co n quer
 Co r rection
 Co n stant
 Co n tinue
 Co - unitarian
 Co n viction
 Co w
 Co x
 Co y
 Co z

Everything becomes now clear as day, and without delay I am in the position to formulate the ensuing apposite conclusions:

(a) No *con*-combinations exist with non-Latin words, *i.e.*, words beginning with *k*, *w*, *x*, *y*, *z*.

(b) Stems whose first letter consists of a vowel or the aspirate are preceded by *co*, though exceptions exist.

(c) In certain cases where the *n* in *con*-combinations would be difficult to pronounce, it becomes *m*, as in words commencing with *b*, *p*, *m*.

(d) For similar reasons as in (c), the *n* in *con* becomes *l* before *l*, and *n* before *r*.

(e) Rules (a), (c), and (d), apply presumably to *in* and other prefixes terminating in *n*, if others should exist—*imbibe*, *im-pinge*, *illegible*, *immaterial*, *irreducible*, etc.

Similar rules are presumably operative throughout the English language in the words derived from Latin, *e.g.*, *rampant*, *effusion*, *diffusion*; or, *ad* adapted as follows: *affirm*, *aggrandise*, *allure*, *ammunition*, *apparent*, *arrive*, *ascend*, *assume*, *attention*.

From this lengthy statement it will be readily inferred that habitual and methodical procedure as a whole, including of course habitual and methodical generalisation, are of prime importance.

The sub-headings in Conclusion 16, pertaining to Observation, should be also utilised in connection with the process of generalisation.

CONCLUSION 26.

Need of Postponing large Generalisations to near the Conclusion of the Enquiry.

§ 173. Useful as is the formulation of comprehensive conclusions at the termination of an investigation, it is mischievous to seek for these at the commencement, for the reason that the conclusions then arrived at are almost certainly premature and are likely therefore to be erroneous and misleading. Until the field under inspection is scrupulously explored, the largest number of conclusions are collected, and the ground is traversed repeatedly, it is well to regard the conclusions reached as

practically of equal value. Towards the close of the enquiry, when verification is easy and misapprehensions are difficult, the conclusions will be gradually valuated, graded, developed, connected, completed, the paramount factors will be isolated, and a point of view elaborated. For instance, the present author, in writing his *Mind of Man*, launched upon his examination of the chief psychological categories current, without reference to any hypothesis concerning their nature, and he is at a loss to conceive why in the investigation of any ordinary problem, except for directive purposes, one should seek to anticipate the final conclusion or expect that such anticipation will be confirmed by the examination. Are the secrets of nature and of life to be more easily elicited by sheer speculation than the melodies which may be charmed out of a violin? The answer of history on this point is conclusive.

CONCLUSION 27.

Need of Exhausting the Degree of Applicability of a Conclusion within and between Divisions, and also of Extending it to Parallel, Distantly Related, Seemingly Unrelated, Pure, Normal, Minimal, Maximal, Deviating, Morbid, Eccentric, Border, and Transitional Instances.

§ 174. (A) *DEGREE-DETERMINATION*.—Bacon, in his analysis of the nature of heat, allowed for degrees of heat. The use here proposed of the term Degree, however, extends further, for in Bacon's analysis we should have gradually passed from intense heat to imperceptible heat and thence to perceptible cold and intense cold, thus challenging his assumption that heat and cold are separable facts; and we should have been obliged to proceed even beyond and inquired as to whether temperature represents a simple quality or a mixture or complex of qualities, and how far it is one of a series of related qualities—how far it is, for instance, related to light and electricity. Similarly, the common notion that attention intensifies a mental state, loses its meaning when this Conclusion is applied, for attention proves to be merely an alternative term for direction and relative concentration of mental activity. If an assertion is made concerning a certain class of objects, we ought to call into question its extending so far, and also learn whether it does not extend indefinitely farther. A Conclusion such as the present one will probably transpire to be most valuable by sometimes narrowing the compass of a generalisation, but more frequently in greatly extending its scope. It may be automatically applied where contrasts are or may be brought in question, such as once and always, one and everything, concretest detail and abstractest generality, particular and universal, simple and complex, large and small, far and near, light and heavy, white and black, summer and winter, good and bad, ignorant and well-informed, beautiful and ugly.

The passage from ether to electron, from electron to the proto-elements, from the latter to the inert gases, from these to ordinary elements and simple compounds, and from the last to colloids and protoplasm;¹ from gases to solids; from freezing point to boiling point; from the electric spark of a toy battery to the flash of lightning; from the readily obtained amount of energy required for effecting the combination of phosphorus with warm air to the at present unobtainable amount necessary for disintegrating a chemical element; from opacity to transparency; from imperviousness to perviousness; from rarity to density; from the feeble draught making its way up a kitchen chimney in sultry weather to a tempest in mid-ocean; from rill to river; from the centre of the earth to its surface and from its surface to the periphery of the atmosphere; from the tremours of a stretched wire to earthquake shocks; from the climate or the stratification of one geological epoch to that of another; from antarctic to arctic zone; from the temperature of trees to that of birds; from the degree of plant metabolism in mid-spring to that of mid-winter; from the bright scarlet colour of arterial blood to the dark purple of venous blood; from complete sterility to remarkable fertility of hybrid and other offspring; from alert wakefulness to profound sleep; from rasping noise to mellifluous harmony; from imperturbable calm to neurotic excitement; from high efficiency to total inefficiency; from verbal exposition to concrete study; from ultra-anarchist to ultra-conservative in politics and other spheres; from Napoleonic artillery effective only at less than a mile range to modern long-distance guns deadly at more than sixty miles range; and from private altercations to world wars; the discovery of the spheroidal nature of the globe, of the planetary perturbations, the variations of the earth's magnetism, and of the presence of carbonic acid in the air in a small

¹ "The degree of chemical complexity capable of existing in the materials found on the earth is definitely and sharply fixed by temperature. At a white heat, such as exists in the sun's atmosphere, we have seen that only elements can exist, and many of these are decomposed into proto-elements. At a somewhat lower temperature binary compounds, such as the oxides, can remain in equilibrium, in incomplete combination, becoming more and more complete as the temperature falls, and, as soon as their existence becomes possible, these oxides do exist. Lower still in the scale of temperature, saline compounds, such as chlorides of the alkalies, and mutually neutralised acidic and basic oxides combined together, can stand the heat. Such bodies as the carbonates of calcium and magnesium can now be present in an incomplete state of combination, partially as oxide and partially as carbonate, in labile balance as the temperature fluctuates up or down, and the pressure of carbon dioxide in the atmosphere changes. Whenever the environmental conditions make their presence possible, these more complex forms must promptly make their appearance by chemical law. But it is only at a very much lower temperature that compounds at all complicated in chemical structure can exist in equilibrium, and for those compounds of many hundreds of atoms which are a characteristic of life, the range is narrowly limited." (Benjamin Moore, *op. cit.*, pp. 184-186.)

but definite proportion, as illustrating the need of a high degree of exactitude; the retardation of ascending missiles through the action of gravity and their parabolic trajectory; the possibility of a continuous transition from the liquid to the gaseous state, as evidenced by gaseous carbon dioxide turning into its corresponding liquid gradually; the difference in the penetrating power of alpha, beta, and gamma rays; the degree of conductivity and compressibility of different substances; the effect of variations in degrees of temperature in determining the consistency of a substance or in producing the trade winds and land and sea breezes; the problem of the pump, and of the use of mercury in connection with the thermometer and barometer; the use of gold-leaf in electrical experiments because of its unrivalled thinness; the quantitative and qualitative differences between the chemical elements; the point of greatest and least density of water and of other substances; steam, cloud, mist, rain, hail, sleet, snow, ice, frost, and dew as forms of water; the state of the earth now and when it was in a gaseous condition; the similarity of the light seen when the temperature of a meteorite is slowly raised in a laboratory with that of a comet approaching the sun; the displacement in geology of the catastrophic by the Huttonian theory; the links which connect the lowliest with the most developed forms of life; the relation of fluctuations to mutations in biology; nerve cells, muscular cells, sense cells, and glandular cells, as modifications of epithelial cells; the significant part played by bacteria and earthworms in the economy of nature; the slow forming and fading of sensory impressions; the problem of attention and inattention, of habit and deliberate thought and action, and of the formation of character; the educative process in the race and individual, and human progress from eolithic to modern times and beyond; the relative moral, intellectual, and hygienic effects of small and large potions of alcohol; the ability to resist appreciable doses of poison through becoming habituated to them by the frequent absorption of inconsiderable doses;¹ the comparative truth and importance of two opposed assertions or courses of action in politics or social life; the slow development of landscape painting from still and dark-green landscapes to landscapes abounding in colour and movement, or portraiture from passivity and stiffness to action and vivacity, of buildings from mud hut to Rheims cathedral, and of music from the primitive man's chant to a Beethoven

¹ "It is only some fifteen years since Calmette showed that, if cobra poison were introduced into the blood of a horse in less quantity than would cause death, the horse would tolerate, with little disturbance, after ten days, a full dose, and then day after day an increasing dose, until the horse, without any inconvenience, received an injection of cobra poison large enough to kill thirty horses of its size." (Sir Ray Lankester, *The Kingdom of Man*, 1912, p. 79.)

symphony; the place of diagrammatic curves in statistical and other studies; and countless other problems—including the bulk of the facts of geology and physiography, the steady growth and further development of the arts, crafts, sciences, and social institutions, and everything capable of being treated quantitatively, need to be classified under this head.

In this way, by using the stereoscope with sets of photographs, taken from half-an-inch to ten inches apart, we convincingly demonstrate that our sense of the third dimension is due, in part at least, to the distance between the eyes. Thus "Sir H. Davy, from finding that the flame of hydrogen gas was not communicated through a long slender tube, conjectured that a shorter but slenderer tube would answer the same purpose; this led him to try the experiments, in which, by continually shortening the tube, and at the same time lessening its bore, he arrived at last at the wire-gauze of his safety lamp". (Whately, *Logic*, pp. 237–238.)

Again. Warm water at rest in an open vessel lacks decidedly the character of a solid; yet "the water a foot or so away from the fireman's hose, may be struck with a hammer, and the latter will rebound as though from an anvil". Similarly, chromium added to steel in a certain proportion renders the latter rustless, and the best incandescent mantle contains a mixture of 99 per cent. of thorium oxide and 1 per cent. of cerium oxide. To borrow an example from Venn: "If we are shown two glasses of water, one from the sea, and one from the Lake of Geneva, no one can detect any difference in their colour. But let us have enough of each in vessels side by side, and any eye could detect the degree and nature of the contrast." (*Logic*, p. 536.) So, too, if we place two ounce weights side by side, no mutual gravitational effect is observable; but a pendulum near a mountain is deflected sensibly. Thus snowflakes appear white in masses and transparent when detached, and the corpuscles of the blood seem red when in numbers and somewhat yellow separately. Anthropology offers us a pertinent illustration of some consequence. Human beings are as a rule strictly divided into white, yellow, and black; yet not only does Prof. Tyler in his *Anthropology* (p. 67) inform us that "on the whole it seems that the distinction of colour, from the fairest Englishman to the darkest African, has no hard and fast lines, but varies gradually from one tint to another", but the facts appear rather to bear witness to a single colour—from the palest to the shadiest yellow. Darwin applies this Conclusion perhaps more frequently than any other: "This feather-mark [the ocellus on the tail-coverts of the peacock] was properly considered a serious difficulty to Darwin's theory because of its remarkable character. But with consummate ingenuity he undertook to connect it by a series of less and less remarkable markings with the ordinary feather-markings of the

group to which the peacock belongs.” (Frank Cramer, *op. cit.*, pp. 58–59.) “The first thing to be established in proof of the derivation of climbing plants from non-climbers was the existence of gradations in the power of climbing, and the intermediate stages between the different methods of climbing—by twining of the stem, by leaf-stalks, and by tendrils.” (*Ibid.*, p. 166.)

§ 175. Lastly. The dimensional theories appear to diminish in persuasiveness when the measure of a high degree of exactitude in analysis is applied. A point, a line, and a plane, as limiting notions, are permissible concepts; but from the standpoint of objective reality we are bound to assume that they convey no distinct meaning. For instance, since, by definition, a point does not, and a line does, occupy space, no number of successive points however great, could form a line however small. Similarly, since a line, by definition, is said to have no width, an infinite number of juxtaposed lines could never form a plane however limited; and since, by definition, a plane has no depth, the superposition of any number of planes however multitudinous, could not form a solid however thin. The three sets of dimensions, as conceived separately, have therefore, it seems, no relation whatever one to another.

From a different standpoint, the same criticism applies if a sufficiently high degree of exactitude is employed. Any actual point must have three dimensions, and so must any actual line and plane. A one or two-dimensioned being is apparently a mere logical or verbal figment. So-called plane beings resolve themselves into three-dimensional beings whom we, for theoretical purposes or owing to an insufficient degree of clarity of thought, regard as two-dimensional. For the same reason, when we speak of four-dimensional beings, we are almost certainly carried away by the verbal decomposition of solids into three parts. As a matter of fact, every conceivable object is a solid, no more and no less. It is as if, misled by a useful division, men reasoned that we could imagine the existence of a single horizontal direction—east, or of horizontal directions, additional to east, west, north, and south, and their intermediates.

Or to illustrate the matter differently. Conscious lines floating in space and coming into contact or collision with other lines, would become aware of the existence of those other lines. If these lines collided with planes or cubes, they would be conscious of them, but only in so far as lines. So with planes, colliding with lines and cubes. The planes would recognise the lines as lines, and the cubes in so far as planes. Accordingly, a four-dimensional being coming into collision with a three-dimensional being would be recognised by the latter so far as three out of the four dimensions are in question. The four-dimensional being cannot consequently live more than one fourth outside the three-dimensional world.

However, ultra-three-dimensional beings are usually thought of as living entirely on one plane, in the fourth dimension. If so, they must be conceived as entirely unconscious of the three other planes. Besides, recent speculations have acquainted us with hypothetical beings having two and three dimensions; but not with beings living exclusively in the second or third dimension. No one, if we mistake not, has yet pretended that such existed or could exist. We certainly are not cognisant of them. Hence a being living exclusively in the fourth dimension, poses a new problem, and raises the perplexing question of the existence of beings living entirely in the second or third dimension.

Whatever way, then, we regard the dimensional problem, it seems—if our analysis is penetrating enough—that nothing but solids exist, and that we are wholly unconscious of the existence of one or two-dimensional beings. Einstein's rigid bodies and mollusks seem to fall both under the same definition. Probably an analysis of the notions of curved spheroidal and finite space would be equally non-confirmative of recent space theories.

§ 176. In practical life, matters of degree are constantly overlooked. For this reason one school will declare itself ostentatiously for the upholding of authority and another of freedom, when wise moderation suggests that the utmost liberty of personal judgment is congruent with the deepest general respect for authority. Similarly, this Conclusion urges the advantage of increasingly more precise, refined, and powerful instruments and methods, which have frequently revolutionised a department of science and general activity, and the need of observation being of the extremest delicacy, of experiments being completely unequivocal, and of calculations disregarding no factor however seemingly insignificant. Moreover, it comprehends all analogical reasoning both in respect of degree and qualitative resemblance, as the analogy between food and fuel or a gland and a lung, or the determination of the ponderable nature of the air by noting that it can be warmed, cooled, moved, compressed, dilated, even seen in certain circumstances, that it rises in water, occupies space, exerts palpable pressure when strongly agitated, behaves like smoke, is capable of producing sound, etc. The Conclusion is also, as we have noted, most especially applicable to the systematic testing of the homogeneity of any content and of the reality of divisions, of the comparative importance or position of two or more related facts, as well as to terms involving degree, contrast, similarity, and, in general, relativity. If Descartes and Malebranche had applied this Conclusion, they would have probably abandoned their favourite terms *Clear* and *Distinct* as terms normally lacking absolute, and needing relative, determination, and M. Henri Bergson would probably find himself left, perhaps,

without any inner world at all if, following this Conclusion, he consistently excluded *all* experience, reflection, and classification.

Furthermore, we alter the degree of an alleged cause for the purpose of perceiving whether there is a uniformly corresponding change in the degree of its alleged effects, and *vice versa*. (This is Bacon's and Mill's method of Concomitant Variation.) *We also search for pure instances, for extremes, for that which may be regarded as the mean or the normal, for deviating, morbid, eccentric, border, and transitional instances, and for any other remarkable stages or divisions between the extremes or between maximum and minimum, endeavouring to reduce all exceptions to rules.* We inquire whether we are dealing with partly or wholly continuous or qualitatively different states. We gradually eliminate constituents in order to observe the residual phenomena which often prove to be of far-reaching significance both theoretically and practically, and also by stages add others with the same object, as in chemistry. We endeavour to arrange all knowledge in a determinate order—atomic weight of chemical elements, specific gravity of substances, influence of time on physical, vital, and cultural components and processes, the evolution of the human eye and other parts of the human body from the earliest manifestation of life on the globe, etc., allowing for veiled or hidden resemblances and dissimilarities, as in subcutaneous processes or structures in the living or superficially different but really homologous vital functions and parts, as illustrated by the "wings" of the bat, the "fins" of the whale, and the electric organs of fishes.

§ 177. Darwin, in his *Descent of Man*, reasoned circumstantially that man was essentially an animal, because in innumerable respects he *resembles* animals. Proofs in behalf of this thesis he offered in profusion, inquiring into every conceivable character which was alleged to be distinctive of man. Throughout, he proceeded on the assumption that differences of degree are of secondary importance. Yet by consistently pursuing such a method he would have experienced no difficulty in proving that all animals are plants, and possibly that no division exists between living and non-living things.

The truth, however, is that degrees frequently indicate qualitative differences. *E.g.*, a black piece of iron, as it is being heated, grows successively red-hot and white-hot; a certain degree of friction produces a spark, and only at a certain stage does chemical combination or decomposition take place. More marvellous still, when the rate of oscillation of electrons is very high, they emit rays which cause the sensation known to us as light, and if "they oscillate even faster than required for this effect, they produce rays of invisible light. Slower oscillations produce rays of heat, and still slower frequencies

give rise to the wonderful wireless waves." Or, to consider a different case: with both parents brunettes, the offspring may be either fair or dark, and with both parents blondes, the offspring is invariably blonde. Again, a certain minimum of learning from the experience of others may be found among some animals; man, however, assimilates the substance of the thoughts of all his kind past and present. Man, therefore, almost infinitely transcends in degree the capacity of any animal for learning from others, and this quasi-infinite difference argues that man has reached a unique stage which knows no limitation to the assimilation of the thoughts of others. If that were not so, we should only have a right to expect in this connection a virtually negligible difference between man and ape.

Similarly with man and his tools. Viewing the matter comprehensively, men may be said to have manufactured and employed thousands of millions of different tools or art-produced means. Compared, therefore, to what is presented by Western civilisation, for instance, the two or three unfashioned tools used by animals, bear witness once more to some exclusive quality in man. Otherwise it would be difficult to explain why man should in this respect surpass almost infinitely any known animal, instead of manifesting only an infinitesimal difference. Had Darwin, therefore, observed not only the abstract similarity, but the colossal degree of the difference, he would have been necessarily obliged to search for the cause which would explain this prodigious departure from animal skill. He might have then perhaps discovered that through man having reached the stage of intelligence (just above the higher apes) where he could freely learn from others, a crucial turning point had been attained in the history of living beings, replacing individual and organic evolution by specio-psychic or cultural evolution. It is, therefore, indispensable that not only bare similarity, but the degree of the difference should be taken account of in an enquiry.

In the opposite direction the same fallacy should be avoided. The reality of progress has been frequently denied, because there appeared to be inappreciable progress in certain directions, and even retrogression in others. A general survey, however, on the basis of a compendious classification, would have yielded overwhelming evidence not only of the reality of progress, but of its vastness and its virtual universality. Examine, for example, in this connection the progress in matters relating to language. "From a few inarticulate calls and cries a vocabulary of a hundred thousand words or more, with a correspondingly developed grammar, is evolved; the evanescent word comes gradually to be fixed by the process of writing, which translates the sounds into sight symbols; the invention of printing follows, whereby, at a trivial cost of labour and with almost lightning-like velocity, what is written may be in-

definitely multiplied;¹ the telegraph is then developed, enabling us to remain in uninterrupted contact with our fellows all over the terrestrial globe; the telephone follows the telegraph, turning dots and dashes into the living, vibrating voice; and this, lastly, is succeeded by wireless telegraphy saving tens of thousands of lives at sea and rendering spiritual intercourse independent of artificial media. If this be not progress, and on a stupendous scale, it would be vain to attach any meaning to the term.

"Or, consider the related problem of transport. Primitive man has no paths and no vehicles. Gradually roads, canals, bridges, tunnels, of a more and more scientific and extensive character, are constructed; and by degrees conveyances innumerable fill the world, propelled by animals, by steam, by gas, by electricity, by petrol, at a speed which would have terrified early man, and comfort-yielding beyond the fancies of lords and ladies of yore. Nor is the solid earth alone utilised. The seas teem with magnificent boats, and the air is beginning to be alive with aircraft. Would not a primitive have regarded such an improvement as outwinging his most daring anticipations of what man could achieve?

"Or, to treat the rest summarily, shall we speak of the startling and superlative advance embodied in modern science, of the varied and brilliant triumphs of the arts, of the horde spirit expanding into the international spirit, of man-sacrificing superstition transformed into man-saving religion, of the rose of morality blossoming out of the briars of barbarism, of the vendetta and the torture chamber issuing in comparatively impartial and humane laws, of despotism forced to yield inch by inch to democracy, of the haphazard acquisition of incoherent suppositions melting into the dawn of an epoch of scientific and systematic education and learning, or of the magic story of architecture from the straw-hut to the marble palace? The more closely we scrutinise the problem, the more manifest it becomes that not only is progress a reality, but that the advance from the use of unchipped flints to that of electrically-driven machinery, from the era of speechlessness to that of collectively-applied scientific methods, has been immeasurably great—so great that the imagination staggers and reels when it strives comprehensively and without bias to envisage the metamorphosis and transfiguration which have taken place." (G. Spiller, *Outlines of a New World Religion*, 1918, pp. 16–17.)

¹ To judge by present achievements, the highest æsthetic education and satisfaction of all individuals will be successfully promoted in the future through art reproductions in the home: the works of the great master painters will be represented in plain monochrome or in the appealing colours of the originals in frames or on walls; those of the illustrious sculptors and artificers will be there in proxy; the sublimest music and song will fill every home; and other adornments, no less magical, will be ubiquitous.

Looking, then, in perspective at the problem of the reality of progress we learn that the negative view loses itself in a sea of trifles and ignores the mountains of evidence in its favour. *Quantity* in proof can only be neglected at the risk of missing a general law.

Yet even a comparatively insignificant degree of difference may be due to new factors. Approaching the edge of a precipitous cliff, this is of no consequence to life and limb until we are close to the edge. Working out a complicated problem, the solution presents itself only at the very end. In this light, it is contended here, ought we to consider man's intelligence. From faintest sensibility, we advance in the animal kingdom to the possession of a number of highly developed senses; from simple and uncertain reactions, we come to complex and definite instincts; and from scarcely perceptible intelligence, we reach the acute sagacity of the higher mammals, and especially of the monkeys and the apes. In the last of these instances the quality and the scope of thought intimately approaches man's. The manner in which the Orang Outang in captivity studies his visitors, and visibly calculates and adapts his actions (see *Mind of Man*, pp. 462–463), is confusingly like man's. Why posit, then, a gigantic distance intellectually between man and ape, when the two appear so closely related? And still, scrutinising the subject circumspectly, we find that the Orang Outang just misses being sufficiently advanced intellectually to profit freely by the thoughts of others. That is, a slight advance beyond the Orang Outang, corresponding in some degree to man's completely erect attitude and his larger brain, furnishes the possibility of freely learning by the experience of others, and this, as is plain, opens a new earth, nay a new universe. Just as the ultimate step at the cliff's edge, or rather the ultimate line in our mathematical problem, translate us, as if by magic, into a fresh world, so the last step in the evolution of the intelligence, insignificant in itself, is responsible for a fundamental change.

We should beware hence of mechanically reasoning in regard to degrees of difference. Great differences of degree may or may not be due to qualitative differences, and small differences may be in exactly the same position. The cause of a difference should be in each case separately and scrupulously inquired into.¹

§ 178. Inasmuch as the present and the succeeding Conclusion are of extreme significance methodologically, we venture to offer an example of how the two Conclusions may be applied

¹ Of course, we should also search for fixed differences. It is believed, for instance, that there are no degrees of inheritance, a factor being either present or absent. Furthermore, *definite* facts and laws are said to exist in abundance, as the chemical elements, the law of gravitation, and the laws of motion.

to a problem, premising that there is here no attempt to exhaust the possible number of aspects. In all investigations we must proceed in this manner if we are to escape serious error, and if we are to proffer an appreciable contribution towards solving a problem. We base the first portion of our example on the now discarded table of Secondary Categories and the second on the table of Primary Categories, emphasising in this place only the former.

(a) State what is the precise object of the enquiry—the nature of habit, and roughly define the term Habit.

(b) Determine whether there is such a thing as a habit at all; whether its existence is relatively doubtful or relatively indubitable.

(c) Determine to what degree a habit may be part of a more comprehensive phenomenon embracing, say, automatic, reflex, and deliberate action, or may be constituted of varying phenomena, including now some psychic factors and now others; or may represent as a totality or in part a qualitatively unique phenomenon; or may enter into the whole or part of the mental life; or may be evanescent or last a life-time.

(d) Determine how far one habit evolves out of preceding, depends on or conditions co-existing, and forms a basis for succeeding, habits and other activities, and determine how far habits differ from one another as wholes or in their parts.

(e) Follow a habit from its one or more lowest, through its one or more normal or perfect, to its one or more highest, stages,¹ allowing for average, casual, momentary, time-produced, environment-produced, transitional, imperfect, perfect, exceptional, abnormal, and morbid characteristics.

(f) Determine whether differences of degree as to any aspect of a habit produce any fundamental or what difference, and whether habits are related by a chain of degrees to other related phenomena such as automatic, reflex, and deliberate action.

(g) Gradually eliminate and also add, one by one and also in groups and in different quantities, the alleged static and dynamic constituents of a habit and apply exact measurement, calculation, experiment, and deductive method.

(h) Trace step by step, or continuously, the evolution, immediate and more remote origin, development, dissolution or transformation, further evolution, and general effects of habits or of a habit, and apply the other modal aspects in the table of Primary Categories.

(i) Allow in the investigation of a habit for possible contradictory, contrary, opposite, common, disparate, dependent,

¹ In following, for instance, the change in volume of water from boiling point to freezing point, we shall be surprised to find that the volume of water, when closely approaching the freezing point, ceases to contract and begins to expand. Only tireless vigilance, which takes nothing for granted, will disclose such eccentricities.

interdependent, complementary, alternative, relative, parallel, and distantly related or seemingly unrelated static and dynamic facts, in or between habits as wholes, or in or between parts of those wholes.

(j) Compare habits under varied conditions, including those most similar and dissimilar.

(k) Determine the degree of a habit's relation to closely, less closely, and distantly connected phenomena in order to reach the most comprehensive relevant statement.

(l) Ascertain the degree of the relations of habits to psychology in general and its applications, to the sciences immediately—and those more distantly—related to psychology, to the sciences and the arts generally, and to the social sciences and their corresponding practical activities.

(m) Lastly. Furnish, after the fullest investigation, the tersest, most lucid, most definite, and most comprehensive statement of the peculiar nature of habit, which approaches to complete exactness and is offered as far as possible in mathematical form.

And in respect of the aim of the investigation, it is necessary, in pursuance of the table of Primary Categories, to determine the Material Aspects (*Elementals*, or precise fundamental sensory and other mental data relating to the nature of habits; *Constituents*, or the precise static and dynamic elements, materials, and parts of a habit, and their precise disposition, connection, and relative homogeneity or heterogeneity; *Form*, or the precise form of a habit; *Dependence*, or the precise dependence of habits on leading and other accompanying phenomena; *Action* and *Cause*, or the precise chief causes and effects of habits; *Resemblances*, or the precise degree and nature of the resemblances subsisting between habits and between habits and related phenomena; *Classification*, or the precise methodical classification of the facts collected and their subsumption under a larger classificatory scheme; *Position*, or precise comparative position of habits within the class or classes in which they fall, and precise comparison of the constituents of different habits; *Differentiæ*, or the precise leading and other differentiæ, of habits, the ascertainment of the leading differentiæ being the primary object of an investigation; *Details*, or the precise secondary aspects or details relating to habits and of interest to the inquirer; *Worth*, or the precise utilisation, application, reproduction, value, quality, appreciation, desire, liking, preference, love, and enjoyment, and their opposites, of habits; *Description*, or precise nomenclature, terminology, and statements in connection with habits) and the Modal Aspects (comprising important items pertaining to Quantity, Time, Space, Consciousness, Degree, State, Change, and Personal Equation).¹

¹ On the nature of habit, see the author's *Mind of Man*, and for an analysis based on the table of Primary Categories, § 102.

§ 179. (B) PARALLEL AND OTHER INSTANCES.—If the “opposite”, as we shall see in the next Conclusion, may show that the contrary of the proposition holds good, and if the Sub-Conclusion relating to degree may in a more elastic way indefinitely narrow or extend the limits of a proposition, the Sub-Conclusion pertaining to parallel cases of facts endeavours to extend an assertion to classes of facts which do not at first sight appear to be closely filiated. For instance, by the Sub-Conclusion of degree-determination or that of opposite instances, the bad man may be proved to possess a conscience which encourages him to commit wrong, and by the present Sub-Conclusion it may be demonstrated that there is a faculty within certain men which informs them not merely of what is right or wrong, but what is inexpensive, what is pleasant, or what is correct. Summing up the conclusions concerning this faculty, we may advance the generalisation that conscience as such implies “familiar activity”, and that whatever class of facts is familiar to an individual gives rise to a special conscience. Equally so with such terms as *ought*, *duty*, *responsibility*, *praise* and *blame*, *merit* and *demerit*, *good* and *bad*: these may each be shown to apply outside of what is strictly called the realm of ethics. The expression “You ought to do this”, for instance, which appears to mean “If you are a certain kind of person (a good man, a bad man, an artist, a man of wit, a physicist), you will do this”, may be applied equally—and is so applied, as daily experience illustrates—to moral, immoral, and non-moral actions. Indeed, where doubt is excluded, the word “ought” is inapplicable. To the good man we say “We know you respect your mother”, and to the bad man “We know you do not respect your mother”. To the former it would be an insult to say “You ought to respect your mother”, and to the latter the word “ought” would lack all meaning on the moral plane.

The extension of the law that heat transforms work, but is not lost, into the general law of the conservation of energy, or that heat, light, and electricity, or various senses, have important properties in common, offer further apposite illustrations. Finally, an application of this Sub-Conclusion is to be discerned in Madame Montessori’s educational method. Observing that she could prepare defective children so well scholastically that they equalled average children of the same age in their intellectual attainments, she reasoned that the application of the same methods, appropriately modified for average children, would correspondingly raise the educative capacity of the latter. This Sub-Conclusion refers to lateral rather than to vertical generalisations, to extending a proposition to more or less nearly related facts which have not been considered as closely related in respect of the particular item or items;¹ indeed, the Sub-

¹ Huxley’s famous essay on “The Relation of Man to the Lower Animals” confines itself to a line of argument in conformity with this Conclusion.

Conclusion bids us keep our eyes wide open, prepared for encountering resemblances in the most unexpected haunts. The present Sub-Conclusion may be also utilised for arriving at the largest number of independent propositions within any topic (see Conclusion 22), and should be utilised for the supremely important object of connecting one science with another, and passing from theory to practice and from pure to applied science, backwards and forwards.

CONCLUSION 28.

Need of Proceeding Dialectically, *i.e.*, need of Searching in connection with any Conclusion for what is Contradictory, Contrary, Opposite, Common, Disparate, Dependent, Interdependent, Supplementary, Alternative, Complementary, and Relative.

§ 180. (a) **CONTRADICTORY.**—For the purpose of checking, verifying, or extending our generalisations, we should be ever actively seeking the *Contradictory*, or the negating of the conclusion which we have provisionally or finally arrived at. This being our goal, we must be eagerly watching for facts which should aid us in placing the short particle “not” before the predicate of the proposition which we have reached.¹ *E.g.*, we convert the proposition “All men are born depraved” into the other “All men are *not* born depraved”, and examine into the truth of the formally modified statement. Or when we meet the assertion that senile decay as such is due to arterial sclerosis, we reflect that sundry living beings have no arteries and yet are subject to senile decay. Thus also reflexes cannot be dependent on nerves as such since tropisms exist among animals which have no nerves; unequal density in gases can be proved to be unnecessary for diffusion by connecting together two vessels containing gases having the same density, and noting the result; vegetable oils and lard may be inferred to be inferior in nutritive value to milk, cream, butter, and cod-liver

He sums up his reasoning in the following sentence: “Whatever systems of organs be studied, the comparison of their modifications in the ape series leads to one and the same result—that the structural differences which separate Man from the Gorilla and the Chimpanzee are not so great as those which separate the Gorilla from the lower Apes”. (*Man's Place in Nature*, 1909, p. 71.)

¹ Chinese moral philosophy illustrates the different views relating to man's moral nature. Confucius and Mencius held that man is born good. Kao declared that righteousness can only be got out of man if we train him properly. Hsun Tzu argued that the nature of man at birth is positively evil. Yang Hsiung contended that the nature of man at birth is neither wholly good nor wholly evil, but a mixture of both. Yan Han Yu asserted that the nature of man is not uniform, but is divided into three grades—namely, highest, middle, and lowest. (Herbert A. Giles, *The Civilisation of China*, 1911.) To this we might add that only the perfect truly satisfies man, but that he may nevertheless be drilled into indifference or hostility to the good.

oil, from the experience that the former, being less expensive, are yet neglected in favour of the latter; typically forced movements in animals are not necessarily accompanied by pain or pleasure, for typically forced movements in human beings are not always accompanied by pleasure or pain; when animals move from the shade to the light, it is not because they "prefer" the latter, for they will do the reverse, if they can thus remain oriented with their heads towards the source of light (Loeb); if certain fish tend to swim against the current, this is not due to the friction of the water, for if the fish be placed inside a bottle and the bottle be dragged through the water, there will be an identical reaction, and the same is proved by either darkness or blindness supervening, for then the fish becomes indifferent to the current. If we hear the Western peoples confidently spoken of as of Aryan, Caucasian, or European descent, we provisionally call into question the correctness of the popular doctrine, and we proceed similarly when we hear it affirmed that the Caucasian race is a separate race, that it is wholly or relatively free from racial admixture, or that it stands inherently higher than other races. Prejudice being an active force in weaving and controlling theories, it is specially important to challenge, *and subsequently to scrutinise*, the soundness of any statement where sex, race, nationality, class, religion, custom, economic considerations, and political party are in dispute.

§ 181. (b) *CONTRARY*.—Similarly with the term *Contrary*, which we also employ in its ordinary logical acceptance. Here we seek to cancel a statement by placing, if possible, a "no" before the subject, as "All men are born depraved", "No man is born depraved". Interest in evolving such negations should be habitual, if only to prove an assertion unassailable, although it will be found surprisingly often that either the contradictory or the contrary of a proposition can be substantiated. The double interest in affirmation and negation will also prevent psychical prejudice from developing. The contradictory entails a qualified denial; the contrary a flat denial. Naturally, whilst demonstrating that the contrary has sometimes far-reaching and startling consequences, it is not probable that we can maintain it as frequently as the contradictory. When, however, two nations, for instance, are at war, it is well to assume, until adequate proof is forthcoming, that all grave accusations by one side or the other, are presumably altogether baseless.¹ (See Conclusion 19*m*.) So, too, the facts of primitive magic and medicine are most profitably investigated by supposing the

¹ This passage was written prior to the World War. In this war, for example, the communiqués of each of the opposing combatants referred almost exclusively to their own successes and to the failures of the enemy, the interpretation of failure and success being frequently casuistical in the extreme.

complete erroneousness of the theories, except on the subjective side. Religious "truths", which imply interference with the order of nature, or a pre-established harmony which ensures the triumph of the good irrespective of human effort, may tentatively fall within the same category of treatment. Again, it has been shown that the Jewish nose is, from the racial standpoint, a distinctly unjewish characteristic, due, according to von Luschan, to intermixture with the Hittites. Helmholtz ascribed a certain important function to the organ of Corti, but when it was pointed out to him that birds were without it, he abandoned this theory, which supports by the way the crucial significance of the comparative and genetic methods in the biological sciences. In all cases naturally, where the contrary is proven, we should satisfactorily trace the origin of the belief. Psychological factors, determined by strong interests and a confused apprehension of the world of fact, will be found to explain many prevalent errors.

§ 182. (c) *OPPOSITE*.—In formal logic we cannot pass beyond the contrary, that is, when we have stated that no man is born naturally depraved, we have reached the outer limits. However, the true and concrete contrary, which we have named the *Opposite*, affirms the "opposite", where one can be predicated. The opposite of "All men are born *depraved*" is "All men are born *good*". If it be contended, for instance, that civilisation originated in the West, or that Eastern civilisation proceeds from a strain of Occidental blood in Oriental peoples, we may, considering the evidence, speciously argue that civilisation originated in the East and that Western civilisation is the result of an Oriental strain of blood in Occidental peoples. In this example, both statements may be crudely correct, the explanation being probably that a mixture of civilisations and of races is universally present and universally beneficial. Thus also, whilst free oxygen is indispensable most generally to living beings, certain microbes die when exposed to it; "one by one the instances of anomalous vapour density, which were so many stumbling blocks to the universal acceptance of a system based upon the law of gaseous volumes, have been shown to be not only not inconsistent with it, but actually so many corroborative proofs" (Thorpe, *op. cit.*, vol. 2, p. 53); in some cases increase of temperature appears to lead to diminished solubility; water, just before freezing, expands; and a dose, according to its size, may cure or kill. Following the Mendelian theory,¹ the same reasoning is applicable to Darwin's contention that small variations in offspring form the foundation of evolutionary transmutations. Again, Darwinians had maintained that only congenital differences could explain the conspicuous cultural differences existing between human groups and individuals. Applying this

¹ Hugo de Vries, *The Mutation Theory*, 1910, 1911.

Sub-Conclusion, we discern that since animal groups and individuals virtually do not vary so far as cultural characteristics are concerned, human groups and individuals should likewise be assumed virtually not to vary congenitally in this respect. Consequently, instead of the theory of natural selection expressly demanding that human groups and individuals should markedly vary, we discover that it expressly demands they should remain unaltered. Similarly the theory of radio-activity suggests now that instead of the earth gradually cooling, as was surmised until recently, it is most probably growing hotter. Astronomy harbours such a contradiction. "The moon at its rising and setting appears much larger than when high up in the sky. This is, however, a mere erroneous judgment; for when we come to measure its diameter, so far from finding our conclusion borne out by fact, we actually find it to measure materially less." (Herschel, *Discourse*, [72].)

§ 183. (d) and (e) *COMMON AND DISPARATE*.—A double aspect should also be recognised: there may be no incompatibility between the principle of relativity and the law of the propagation of light; nitrifying organisms abstract nitrogen from the air, but certain bacteria reverse the process; certain animals may be at one time positively, and at another time negatively, heliotropic; defects or virtues in one civilisation may be present also in another ("six of the one and half a dozen of the other", says the accepted proverb); an unfavourable rate of exchange discourages buying and a favourable one selling; some States succeed in one way, and some in an opposite or different way, in dealing with certain social problems; certain culturally backward peoples possess certain simian characteristics which Europeans are without, but Europeans have other simian characteristics which culturally backward peoples do not possess; bracing winds build up one man's constitution, wreck another man's, and leave a third man's constitution unaffected; excitement now benefits and now injures a person; not only may fatigue be induced by injecting into an animal the toxin produced by fatigue, but possibly fatigue may be removed by introducing the complementary anti-toxin; binocular vision commonly emphasises the third dimension, yet monocular vision sometimes exercises the same effect, as looking at a good landscape picture with one eye closed; the plants which abstract carbonic acid from the air, also abstract oxygen; the earth attracts the unsupported stone, but the stone also attracts the earth; two unrelated individuals bear the same name; owing to unequal digestibility, a certain food of a higher nutritive value may be less nutritious than a certain other food of a lower nutritive value. If it be argued that social life betokens a sign of superiority and of advantage in the evolutionary struggle, we may reason as follows: "We are naturally much impressed by the habits of social bees, but we may notice that

the solitary wasp, for instance, is not less remarkable in its 'instincts' than the social wasp. If the social parrot is an advanced bird, the social duck and many other social birds compare unfavourably with the solitary birds. If the beaver has a remarkably complex activity (in which, however, we detect no intelligence), the social deer or buffalo has not. The highest non-human animal, the anthropoid ape, is not a social animal; in fact, the more socially inclined gibbon or gorilla is less intelligent than the less socially inclined chimpanzee or orang." (Joseph McCabe, *The Principles of Evolution*, 1913, p. 66.) In the same way with protective colouring: "In regard to the Arctic animals we find that dark animals are more common than white. Of the Arctic mammals three are perpetually white, five changing with the season, and ten are coloured; the birds show about the same proportion. This objection might be weakened, perhaps, by a more precise indication which of these animals are settled, or have long been settled, in regions of perpetual snow, by setting aside the aquatic mammals (walrus, whale, etc.), and by studying the value of protection in each case. Yet a difficulty remains when we find that only one goose out of many in the Arctic zone is white, one seal out of many in the Antarctic is white, and the Arctic fox is both white, coloured, and variable in different species." (*Ibid.*, p. 119.) Or if we sarcastically expatiate on the ambitions, foibles, or masterfulness of a competitor, we may profitably ask ourselves how far we see our own reflection in his feelings and actions. Again, blankets preserve heat as well as cold, and exposure acts similarly on hot and cold objects.

§ 184. (*f*) and (*g*) *DEPENDENCE AND INTERDEPENDENCE*.—Facts tacitly conceived of as independent, should be tested in regard to whether they are dependent on one another, as growth on the accessory food factors, or mother's milk on the food eaten by the mother; and, if dependent, as to which is cause and which is effect.

Furthermore, series of facts should be also studied with a view to ascertaining whether they are interdependent—as in double stars; in the gaseous laws of Boyle, Dalton, and Gay-Lussac; in the relation of temperature to pressure; in the liquefaction of gases; in seemingly unrelated neighbouring plants; or in the main aspects of mind.

§ 185. (*h*) *SUPPLEMENTARY*.—We should, of course, beware of positing one cause or fact when research might reveal a number. § 155 deals specifically with this problem of endeavouring to supplement what is given. Thus our patent foods are said to be seriously deficient in the three accessory food factors; metals are, generally speaking, lustrous, ductile, malleable, insoluble, fusible, and conduct electricity; the alpha, beta, and gamma "forms of radiation render gases electrically conductive, excite luminescence or fluorescence in certain substances, change the colour of glass, convert oxygen into ozone

and yellow phosphorus into red phosphorus, and act upon photographic plates" (Thorpe, *op. cit.*, vol. 2, p. 42), and "the mean velocity with which the molecules of a gas move can be calculated if we know the pressure it exerts, the weight of a definite volume, and the value of the acceleration due to gravity" (*ibid.*, p. 71).

Thus climatic changes, migrations, novel classes of food, physiological adaptation, sexual selection, segregation, and other factors, may severally be responsible for the trend of evolution, as colouring in animate beings may be due to mimicry, or to the value of protection, warning, and attractiveness combined; the cause of criminality may be manifold—exceptional temptation, bad companions, economic circumstances, faulty upbringing, imperfect or no schooling, lack of vocation, unemployment, alcoholism, poor health, and inferior intelligence; again, moral conduct should be distinguished by all, rather than by one or a few of, the powers of the mind being utilised, whilst only he should be regarded as truly cultured who has highly developed all sides of his distinctive humanity, and not only some sides; and that a subject or object should only be esteemed adequately examined when every important relevant aspect is taken into consideration. Again, reproduction is effected by fission, budding, regeneration, hermaphroditism, and bisexually; and numerous elements have been gradually discovered in the bodily constitutions—carbon, hydrogen, oxygen, nitrogen, sulphur, phosphorus, iron, sodium, potassium, calcium, magnesium, chlorine, iodine, fluorine, silicon, and lithium. So, too, climate should be conceived as dependent on proximity to sea and mountains, position in regard to prevailing winds, forests, deserts, watersheds, altitude, latitude, and configuration and soil of a district, whilst the agents of denudation should include, at least, rain, rivers, ice, frost, heat, the sea, and wind.

Accidents in factories are largely due to unprotected and inefficient plant; to inexperienced, new, and ill-trained men; to bad tools and tools in bad condition; and, of course, to fatigue, indisposition, and carelessness. Types of men may be classed as mental and manual, settled and roving, indoor and outdoor, directive and dependent, minute and comprehensive, adaptable or self-satisfied, deliberate and impulsive, static and dynamic. In fatigue we have to consider the draining of energy, the accumulation of waste products, and the exhaustion of nerves and of the central nervous system. The tests for fatigue, again, are measurement of reaction time, of acuity of sight and hearing, and of blood pressure. "Matter, whatever its origin, cannot be pronounced alive unless it is capable of assimilating the unlike, of producing anti-bodies, of reproducing itself, and of undergoing spontaneously a certain degree of morphological differentiation." (D. Fraser Harris,

“The Specific Characteristics of Vitality”, in *Science Progress*, April, 1916.)

The search for plurality of causes falls under this heading. In all genuine scientific research supplementary classes of facts and factors are hence continually being searched for and discovered.

§ 186. (i) *ALTERNATIVES*.—We must equally allow for alternatives; a certain gas may be a new element with atomic weight 3, or it may be an unsuspected allotropic form of hydrogen, H_3 ; the accessory food factors may prove to be essential structural components of living tissues, or act as necessary catalysts; in weak light an organism may be positively heliotropic, in stronger light indifferent, and in strong light negatively heliotropic; the ground of punishment may be expiation, retribution, deterrence, or reformation; or a person convicted may have the option between imprisonment and paying a fine. Alternatives repeatedly remain unsuspected: “There were two hypotheses to account for the existence of the great terraces called benches, or parallel roads, of Glen Roy, in Scotland”. Of the two hypotheses—marine or lake origin—Darwin decided for the former; but the later and real explanation proved them to be of glacial origin. “My error [Darwin said] has been a good lesson to me never to trust in science to the principle of exclusion.” (Frank Cramer, *op. cit.*, pp. 43, 45.)

§ 187. (j) *COMPLEMENTARY*.—We should endeavour to ascertain whether a conclusion does not suggest an opposite conclusion, and then discover whether the two conclusions are not complementary. This will be found to be the case wherever there is interdependence and interaction, as in the relation of neighbouring plants, animals, social groups, ideational complexes, and inanimate substances, or in the universal instance of action and reaction.

§ 188. (k) *RELATIVE*.—Formal logic deals with extremes, and we should also, in a sense, aim at extremes, that is, at rounded and definite statements. At the same time relative results or particular propositions should be welcomed. “Some men are, or have been, to some extent, born partly good and partly depraved”, “some men will be born very good”, and all possible intermediate stages should be conceived as alternatives, between no exception at all to no order at all. Herbert Spencer reasoned in his *First Principles* that since there was a likelihood that the religion of the past embodied a verity, therefore religions will always remain. In arguing thus he inadvertently overlooked the logical fact that religion might have served a useful and even noble object in the past, but may in the course of time lose its value, as is abundantly true of many ancient and present social institutions. Absolute statements should be only aimed at in the final conclusion. Besides, if the application of this elevenfold Conclusion brings to light

new particulars or generalisations, instead of supporting or negating old ones, the gain is equally real.

The following may serve as a model, for practice or for general application, of this and the last Conclusion. Point of departure: "Every dog has his day." Elaboration: Every dog has not his day; No dog has his day; Every day has its dog; Every dog has its day and every day its dog, and every dog has its day as well as its doom, etc.; Every dog has its day, but not every day its dog; Every dog has his many days; One dog may have his day and another his hour; Every dog depends on his day; Every dog depends on his day, and every day on its dog; Every dog acts on, and reacts to, his day; Some dogs have their day, their hour, their week, sometimes, somewhere, somehow; Some poodles, some newfoundlands, . . . have their day; some cats, some bees, some oaks, some rivers, have their day; Only one thing has its moment; All things have their eternity; Every dog has his bone, etc., etc.

§ 189. In all the Sub-Conclusions mentioned above—from (a) to (k)—we assume that given any conclusion provisionally arrived at, we *deliberately* seek for what is contradictory, contrary, opposite, common, disparate, dependent, interdependent, supplementary, alternative, complementary, and relative.

The almost total disregard of this and the preceding Conclusion is the normal and cardinal defect of most investigations. These two Conclusions, which are neither abstruse nor recondite, should receive, therefore, particular attention, and be applied constructively by investigators and destructively by their critics. Their rigorous and fruitful application is, of course, almost impossible when many statements are advanced, and it is hence essential for thinkers to be well informed in regard to facts, to set their faces against bias and dogmatising, to be in constant consultation with others, and to write little.

SECTION XXIV.—VERIFICATION AND PROOF.

CONCLUSION 29.

Need of Verifying and Proving all Conjectures.

§ 190. A generalisation remains intrinsically a hypothesis until it is verified. Accordingly its scientific value becomes apparent only when, through the act of verification, it has shed its hypothetical character. For this reason we shall now concern ourselves with the process of verification, which process, of course, is not confined to the verification of hypothetical generalisations.

The lowest form of verification is that of ascertaining whether we have correctly observed a particular fact. Well-trained observers can largely dispense with this form. (§ 124.) Since, however, it is always probable, especially with the majority of investigators, that something has been incorrectly apprehended, this form of verification should not be neglected. Such veri-

fication, however, is not equivalent to re-examining the facts, for in the latter case we strive to augment, rather than to revise, our information.

In generalising we pass beyond the scrutinised facts, and, therefore, unless we are, for instance, concerned with a chemical element or a kinetic problem, where the part fitly represents the whole (Section XIII), it is necessary to test the correctness of the generalisation. Wherefore, if we should surmise that a low state of civilisation argues invariably a more poorly endowed race, we are bound to apply every manner of test, especially Conclusion 28, to ensure that we are not mistaken, for possibly other explanations may more satisfactorily interpret the known facts. Without verification, generalisations remain hypotheses which, as a broad rule, are more likely to prove erroneous than true.

It is the same with deduction. A deduction may be made for the purpose of verifying a hypothesis or in order to extend knowledge, as when we infer the existence of positive electricity from the existence of what is called negative electricity, or posit the ether in order to avoid the problem of action across empty space, or argue for the materiality of the ether from the fact that light and other forces are transmitted through it at a quite definite rate (as sound through air which is indubitably material), or seek to prove the double generalisation that transparent solids are good insulators and metals and good conductors opaque by ascertaining the truth of the inference that then the transparent film of a metal would have lost its conductivity. In both connections, the process of reasoning should be tested in regard to their correctness, and the facts should be examined in either case, inasmuch as the hypothesis or the deduction may be unwarranted.

Lastly, where the memory, the imagination, and the processes of reasoning are concerned, the like need for verification manifestly exists.

Given, then, the universal need for verification, we can only add that its methods are those of observation or meticulous scrutiny, as enumerated in Conclusions 16 to 24. Casual or partial verification is, if possible, even less admissible than casual or partial observation.

In Section XIV and Conclusions 8, 19, and 20, and in other places, special expedients for verifying or testing facts have been recited, and to these we would refer the student. We require, then, tests, dealing with science as a whole, with special classes of sciences, with particular sciences and with individual portions of particular sciences, and with particular enquiries. None of these can be dispensed with.

For the sake of completeness we may indicate some of the lines along which proof of an assertion may be conveniently sought. Direct proof may be obtained by (a) simple and

instrumental observation and scrutiny; (b) simple and instrumental experiment; (c) enumeration, measurement, and calculation; (d) obvious or involved deductive testing; (e) confirmation of a prediction by discovering its basis or awaiting its fulfilment; (f) special tests, such as are commonly applied or otherwise prove effective; and (g) applying all or more than one of the above methods. Indirect proof, especially referring to causes, may be obtained by noting in a virtually interminable series of cases drawn from exhaustively varied sources and circumstances, (a) invariable agreement, (b) invariable difference, (c) invariable concomitant variation, (d) invariable residue, and (e) applying, in any particular case, several or all of these methods in conjunction, as in Bacon's method of investigation. The dialectical procedure recommended in Conclusion 28 should be also applied, and, failing complete proof, the degree of proof should be stated. In respect of the matter of the proof, nothing short of ascertaining the unmistakably precise static or dynamic constituents (mechanical, ethereological, physical, chemical, crystalline, biological, and cultural) should be aimed at, or, if this cannot be satisfactorily achieved, the degree of completeness of the apparent proof needs to be recorded.

To verify a fact is not necessarily to explain it, *e.g.*, we possess much verified knowledge concerning the law of gravitation; but few scholars are satisfied that the law is an explanation of the facts. Yet a particular fact is for all intents and purposes explained when it can be shown to be in agreement with some established fact more general than itself.¹ Consequently, the student should strive not only to establish comprehensive laws of nature, but to prove given statements by producing satisfactory evidence that they are special cases of an acknowledged general fact. This is the ideal to be aspired to; but, as we saw earlier, large working hypotheses, and any kind of established propositions, may be utilised in proving or explaining given facts. In other words, we should first seek to verify, and then to explain, facts. We should, however, remember that accord with theory is only to be regarded as complete proof if no other theory is admissible which would equally well or better explain an order of facts.

¹ "An individual fact is said to be explained by pointing out its cause, that is, by stating the law or laws of causation of which its production is an instance. Thus a conflagration is explained when it is proved to have arisen from a spark falling into the midst of a heap of combustibles; and, in a similar manner, a law of uniformity in nature is said to be explained when another law or laws are pointed out, of which that law itself is but a case, and from which it could be deduced." (Mill, *Logic*, bk. 3, ch. 12, § 1.)

"The truth of a given proposition is finally to be proved only by showing that it is not inconsistent with any other propositions which we profess to hold as certain." (J. M. Robertson, *Letters on Reasoning*, 1905, p. 237.)

SECTION XXV.—INTERIM STATEMENT.

CONCLUSION 30.

Need of Exhausting and Gradually Consolidating Lines of Inductive Enquiry and of Aiming at a Balanced Interim Statement.

§ 191. (A) *EXHAUSTING LINES OF INDUCTIVE ENQUIRY*.—We reach now a more general and self-explanatory Conclusion. Not only should we seek to exhaust classes of relevant facts and the conditions under which they subsist; but we should, as far as possible, solidly exhaust every line, whatever direction it takes within that enquiry. Under this heading fall especially the filling in of the interstices between one generalisation and another, the connecting of generalisations, the extending a generalisation to the furthest limits, and testing and extending by deductive procedure. Any inferences or processes of reasoning ought to be also exhausted. In short, when the final conclusion is established, the problem, except for disguised, unimportant, and extraneous implications, should have been, for all intents and purposes, dealt with as far as possible exhaustively.¹

§ 192. (B) *CONSOLIDATING LINES OF INDUCTIVE ENQUIRY*.—The progress of an investigation cannot be ordinarily compared to a straight line, *e.g.*, first observing an object, then ranging this into a class, and ultimately forming ever larger classes, and drawing inferences. On the contrary, an investigation needs to proceed simultaneously in sundry directions. For instance, wishing to make a study of the nature of the sensations, I begin to collect the facts relating to the special senses. I also seek for their mode of development, for their connection, for their possible unity, for their relation to the memory, and so on. How such series of facts are to be linked is not usually manifest at first sight. Consequently, as the enquiry proceeds, tentative attempts are periodically instituted to consolidate it, and this process is repeated with the progress of the investigation, until the totality of the results are as nearly as possible revealed. This does not signify a mechanical consolidation, but a series of rearrangements out of which many suggestions arise for novel lines of investigation. Especially as the general problem approaches solution, will consolidation prove of consequence, and the final attempts may lead to the discovery of much which was unanticipated. This is admirably illustrated in the very gradually and very indirectly obtained gaseous laws of Boyle, Dalton, Gay-Lussac, Avogadro, and Graham, which now tend to be explained by the single hypothesis that a gas represents

¹ "An investigation, by stopping short of exhaustion of the field, may lead, not only to imperfect, but to false, conclusions." (Frank Cramer, *op. cit.*, p. 198.)

a mass of molecules which move intermittently and with extraordinary swiftness.

§ 193. (C) *BALANCED INTERIM STATEMENT.*—*The ideal consummation of an enquiry would be to satisfy fairly the requirements of the table of Primary Categories. The enquiry would lay bare the broadest general facts or leading differentiæ relating to the phenomenon, together with its more important subsidiary laws or secondary aspects. It would yield the precise static and dynamic constituents, as well as the causal connections and the relevant accompanying phenomena. It would determine the precise degree and nature of the phenomenon's chief resemblances to other phenomena, the comparative position occupied among related phenomena, and would irreproachably classify, and subordinate to larger generalisations, the facts and conclusions arrived at. The final statement, as distinct from the interim statement, should also allow for the precise utilisation, application, reproduction, value, quality, appreciation, and, if possible, desire, liking, preference, love, and enjoyment of the phenomenon. Furthermore, the principal modal aspects of the phenomenon relative to quantity, time, space, consciousness, degree, state, change, and personal equation, should be furnished. Should such a consummation be unattainable, we ought yet to provide that an enquiry, when concluded, approaches this ideal as nearly as circumstances permit.*

We will venture on an illustration. Let the subject of the enquiry be the nature of bodily pain. We may reach the conclusion that the so-called sensation of pain is not the pain itself, that pain (or pleasure) is not the invariable motive of action; that men shun acute pain and therefore poverty and misery which engender it; that we do not and cannot as a rule sum or remember pain, and that some persons are more susceptible than others to pain. If these conclusions alone are established, we ought frankly to confess that we only offer a miscellaneous assortment of important statements which do not inform us as to the nature of bodily pain.

A balanced final statement, free from marginal reasoning, would, initially, contain the solution of the central problem—that is, in this connection, inform us concerning the nature or fundamental differentiæ of bodily pain. It might assert the existence of (a) appreciable injury, direct or indirect, to some portion of the sensitive parts of the body; (b) sensations arising out of that injury; (c) a simultaneous central nervous disturbance at first exciting and then depressing, leading to (d) instinctive or deliberate attempts, or to both, to allay the disturbance or to remove its cause. Now inasmuch as an injury, and the sensations connected therewith, may normally exist without involving pain (as when we fix the attention sharply on the persisting sensation), these cannot be the pain, and since

the allaying or removal are subsequent, therefore the exciting or depressing nervous disturbance, it seems, must be the pain, provided no factor or effect has been overlooked. Granting (c) to be a justifiable assumption, which is problematical,¹ we then marshal connectedly the most important apposite facts as required by the table of Primary Categories, including, *e.g.*, the special facts relating to the universality, calculability, variability, degree, recollection, influence, fear, defiance, suppressibility or otherwise, of physical and other pain. If we then strictly circumscribed or fused pain and pleasure, demonstrated the relation in which the two stand to each other, and their relation to other main facts of mind, including preferably their relation to action and reflection generally, our task would be truly concluded. Nothing less than a systematic approach to such a balanced conclusion, expressed in a tersely worded definition where the central facts are all in the focus and are arranged in an intrinsically articulated manner, should receive scientific sanction. An interim statement of this character forms alone a fit introduction to, and basis for, the process of systematic deduction, a process which completes the process of generalisation, as it is itself completed by the process of application.

Having methodically ascertained all the features common to every form and degree of the phenomenon investigated and traceable in no other phenomenon (*e.g.*, heat as a determinate mode of motion), we ought to proceed methodically to the last, but not the least, important step. This is to sum up the inductive part of the investigation in a crisp and comprehensive interim statement. Such a plan is easier conceived than executed, and it is probably owing to this fact that here, as in most other methodological directions, any kind of prolix, and usually incomplete and imperfect, statement is preferred. If, however, we consider the permanent and conspicuous advantage of a fully adequate statement, the widely prevalent unmethodical procedure to-day should no longer commend itself to circumspect thinkers. Moreover, since theoretical and practical deductions might be necessary, such a form of statement is of inestimable value and should be unconditionally demanded, if for no other reason. The mathematical formulæ and definitions, so common in scientific work, are an excellent illustration of the almost infinite superiority of strict definition over casual summaries. How far definition and definiteness should be resorted to beyond the purpose contemplated in the present Conclusion, we shall see below. The question of a balanced final statement, which also comprises the results of deduction and application, will be dealt with in Conclusion 34.

¹ In the lowliest forms of life repulsion and attraction are probably automatic. In somewhat higher forms they are automatic, instinctive, frequently accompanied by feeling, and modified by habit. In man they are further affected by will, reflections and sentiments.

SECTION XXVI.—DEDUCTION.

CONCLUSION 31.

Need of Strenuous Mental Application in the Process of Deduction, and need of the Deductions being Graded, Comprehensive, Important, Numerous, Full, Rational and Relevant, Original, Automatically Initiated, and Methodically Developed.

§ 194. In generalising facts we seek for such similarities as might lead us to formulate a truth larger than the facts we set out with initially. In the descending or deductive method we search also for resemblances, but of a more restricted order than the point of departure of the deduction. In the former process we begin normally with facts; in the latter invariably with a statement.

Concurrently certain methodological differences between generalisation and deduction require to be elucidated. Roughly speaking, in generalising we mechanically affirm of a whole class what we had observed in a section thereof. *E.g.*, for the word *some*, we place the word *all*. If we reversed the process, and for the word *all*, placed the word *some*, and called this deduction, we should be trifling in a serious matter. In the first case, we should have a statement of some consequence; in the second, one of no moment. Deduction, therefore, argues a movement which is not methodologically self-evident, as is the movement in generalisation. *E.g.*, "Socrates is mortal", is not a self-evident conclusion from "All men are mortal", for "Plato is mortal", "The Phrygians are mortal", would have been as appropriate. Whilst in generalising there is but one step—from many particulars to one general; in deduction there may be innumerable steps—from the one general to the many particulars. Once more we see, therefore, that there is a profound distinction between generalising and what we may term particularising. At the same time we should note that in the verifying of certain generalisations, we had to proceed deductively, precisely as if our object were to elicit new truth from an established generalisation. In this sense, deduction may be regarded as an auxiliary process in the establishment of a generalisation. Yet we should not exaggerate the difficulties inherent in the deductive process. As in verifying an ordinary generalisation we are greatly assisted by the thorough knowledge of our subject as a whole, so in deducing we depend to a decisive degree on our intimate acquaintance with the body of truths involved. Total ignorance would spell operating in a mental vacuum.

There are at least two conditions controlling deductive procedure. First, an induction may not be full, that is, only a general statement accompanied by few particulars may have been published; in which case we may deduce the important statement

involved in the general statement. *E.g.*, the one who framed it may not have been aware of all there is known concerning the subject in question; he feels constrained to skip facts yet undiscovered; or he may judge it superfluous to attempt to state in his work everything relevant to the problem treated of. To furnish a concrete example, Darwin was necessarily compelled to leave his statement relating to the evolution of species so incomplete that thousands of men of science have been engaged since helping to complete it. Secondly, a generalisation may be comparatively full, but it may yet be further exploited to enable us to bring to light secondary implications. *E.g.*, a psychological statement regarding the nature of attention may exhaust all that might be asserted with profit psychologically, yet such a statement might be usefully applied, for instance, in æsthetics, in ethics, and in pedagogy.

The above two conditions may be fulfilled in the ensuing ways:—(a) by continuing to proceed inductively, and (b) by proceeding deductively.

(a) We seek to fill in the incomplete statement. We traverse the ground passed over by the framer of the generalisation and discover as many new and material statements as possible. We similarly fit into the structure of the detailed generalisation any freshly discovered facts. If only certain phases interest us, as is commonly the case, we shall, of course, only re-traverse the ground in the measure requisite for our purpose. Our method, then, is to tread in the steps of the original investigator, and, by exhausting all the methods of generalising procedure, to supplement his work by appropriate minor generalisations.

(b) We seek to extend the statement to other spheres. *E.g.*, we apply the laws of attention to pedagogy. In this process we examine either (1) certain minor generalisations—(*e.g.*, in the major generalisation that man is a specio-psychic being, we select the minor generalisation that scientific truth is a pan-human product, and, regarding it in its turn as a major generalisation, we sedulously explore it)—and treat them for our purposes as major generalisations which are to be probed, or we take (2) the major generalisation and develop it in spheres outside the particular section of science or beyond the science itself, as the psychological law of attention in pedagogy. In (1) we attempt what the inquirer would have essayed who had made a study of the facts of how truth is produced or found, save that we possess a guiding thought. That is, we examine and ascertain the modes of discovering truths, and deduce a series of important minor generalisations (which, in their turn, can be treated as major generalisations). In (2) we apply most especially the Conclusions relating to parallel instances, then to degree, contradictory, contrary, opposite, etc., and proceed as in (a). *E.g.*, I examine all the instances where the attention enters as a salient factor in æsthetics, or in any of the cultural

or specio-cultural sciences, with a view to discovering where and to what extent attention enters as a factor.

In any relatively new subject of enquiry deduction plays at the commencement a subordinate part inasmuch as any statements then reached are almost certainly of practically no value and therefore worse than profitless for deductive ends. Nevertheless, we should test even then all our statements in a *passing* manner, because some suggestive minor deductions may emerge. As the investigation develops, and we reach more and more definite conclusions which we express in the form of careful, though provisional, definitions, deduction becomes increasingly important since we can employ it more and more to test, and indirectly to enrich, our conclusions. When the inductive enquiry is on the point of being concluded and comprehensive definitions are formulated, deduction assumes superlative importance, in that it, on the one hand, probes to the depths the value of our results, and, on the other, places us in a position to gather in a definite form the main implications of our investigation. In Conclusion 13 we sought to illustrate this. We assumed there that we had reached the conclusion that man alone is dependent on species-produced thought, and from that we deduced twelve subsidiary practical conclusions of capital import. Regarding one of these conclusions as a fresh point of departure, we might deduce from it an entire department of conduct. These secondary conclusions are in great measure no doubt not novel to the framer of the fundamental definition; but the definition, deductively explored, reveals much that is new, tests everything otherwise reached, ever suggests fresh truths and investigations, and confers a rigidity and reasonableness on the main conclusion that no other method affords. Accordingly, *generalisation and deduction are in no sense processes which can be advantageously separated, especially when we consider that in the process of deduction advantage should be taken, per contra, to generalise as far as possible the statements deduced.*¹

§ 195. An apt illustration of deductive procedure is provided by the solutions of some of the problems of temperature. From observations in regard to the dependence of plant growth on a relatively high temperature, the hothouse was gradually evolved. Much later, analogous observations gave birth to the incubator. The cognate problem of heat-retention in cooking suggested the self-cooker and also certain appliances having for their object the prevention of heat waste in the preliminary cooking

¹ "It is very important to observe, that the successful process of scientific enquiry demands continually the alternate use of both the inductive and deductive method. The path by which we rise to knowledge must be made smooth and beaten in its lower steps, and often ascended and descended, before we can scale our way to any eminence, much less climb to the summit. The achievement is too great for a single effort; stations must be established, and communications kept open with all below." (Herschel, *Discourse*, [184.].)

process itself. Profiting by scientific experience, the thermos flask came into existence. And, on the other hand, ice storage, and particularly cold storage and refrigeration, have been realised on a gigantic scale. Similar applications have been made in regard to the problem of preventing the appalling waste of heat in furnaces, and also in open fire grates—from 80 to 92 per cent. So multiform, in fact, is the practical temperature problem, that it might have with advantage an international institute exclusively devoted to its solution. Concentrated attention to the principles involved, and systematic deduction of the implications, could be pursued there with enormous benefit to mankind. Without doubt, those concerned in the kindred problems of the most economical distribution and use of fuel and the discovery of new sources of relatively inexpensive heat and power supply, should also possess an international habitation, and work in close co-operation with the above institute.

Consider, again, a case in medicine. Somebody finds that fruit acts as a strong laxative, or that the consuming of some other substance induces decided stringency. From the symptoms reported to him, the alert physician tentatively infers, conditionally and within limits, that these substances have probably an analogous, though weaker, effect, even where there is no obvious or direct sign thereof. Had he merely generalised, his conclusion would have been, as is evident, immensely more restricted. Pursuing this method systematically, by generally reasoning from conspicuous to inconspicuous cases—*e.g.*, in everything relating to food factors, nervousness, fresh air, exercise, self-control, existence of certain diseases, etc.—he rationalises his art and makes numerous valuable discoveries. He may proceed a step beyond. Returning to the first example, he may seek to discover what ingredient in the fruit is mainly responsible for the result noted. If successful in his search, he infers that he need not proceed empirically, but that he may find the laxative suitable for different circumstances, persons, and ages, and obtainable in the most convenient and economical form. He may also conditionally infer that if a certain property exercises a certain laxative effect, the opposite property, if it exists, will have a correspondingly astringent effect. Moreover, he may infer that the states he is dealing with, are only instances of more general, but obscured states, and draw appropriate conclusions. Needless to say, what is here done by the physician, may be, with equal advantage, attempted in the arts, crafts, and sciences generally.

§ 196. We shall offer a further explicit illustration of deductive procedure. Suppose we accept the definition of ethics submitted in § 110. We proceed then deductively: "Co-operation being the key-word of ethics, satisfaction of unclarified desires, competition, and exploitation, in any and all spheres of

life, are proved to be non-ethical or unethical. Nor is that species of co-operation which entails antagonism to any one, consonant with the plain meaning of co-operation. Furthermore, since the term co-operation is restricted by no adjective, co-operation should take place, as far as possible, between the whole of mankind, and we need to aim at it in the family, in economics and politics, in international affairs, in art and science, and in daily life. Again, if co-operation is to be effective, there should be, supplementary to an acquired fixed habit of co-operation, the *desire* to co-operate, and if this is to exist, co-operation must be capable, *inter alia*, of satisfying human nature, both as to the object which it is to minister to and as to itself. Since co-operation, moreover, represents by hypothesis an irresistible historic growth or tendency, it can only be alleged to prevail unchallenged when and where human solidarity is completely established and rooted. Towards this end men press since they desire co-operation, and so far as our state of society falls short of the solidarity of mankind, so far is it removed from the termination of the historic process. However, since co-operation forms a historic growth, we shall not be always able to act in conformity with our final ideal as conceived to-day, though we should seek to satisfy it as far as we can. Once more, since co-operation is a progressive pan-human product, it follows that (*a*) as individuals we depend primarily on the conclusions which mankind has arrived at, and not primarily on our own experience and reasoning; hence (*b*) our thought and character are determined by our cultural environment primarily; consequently (*c*) we should aim at a co-operatively developed science of methodology and ethics, for of ourselves we know and effect virtually nothing; (*d*) we should promote co-operation or ethical advance in all departments of life; and (*e*) we should, since the individual is far from self-sufficient, be broad-minded, modest, and eager to learn and serve, whilst putting forth the most strenuous efforts and striving after the greatest originality in order to contribute our full share to the common stock. Again, the definition implies that co-operation should also constitute the characteristic method of the inner life, and that a personal, social, and pan-human life-ideal should replace action decided by more or less momentary impulses and desires. Finally, by co-operation we mean both (*a*) working together directly and (*b*) working together indirectly, *e.g.*, (1) writing a book in collaboration, and (2) disseminating the ideas contained in a book written by some one else.

§ 197. Hypotheses used to play a large part in the generalising process, that is, a man trusted that by reflecting over a few facts known or surmised concerning a subject, the master fact or facts would present themselves to his mind. This procedure is frequently indulged in in all walks of life, and, of

course, not without a modicum of success, more especially where the data are patent and admitted. If, then, guessing at a generalisation has sometimes its reward, it is manifest that deductive divination is much more likely to be crowned with success, inasmuch as the generalisations or statements whereon it is grounded, if the outcome of scientific labours, offer distinct and reliable guidance. Yet both generalising and deductive conjecturing represent a crude substitute for orderly scientific procedure, and may be only rightfully employed where, for the time being, the intricacies of the subject permit of no other advance. Deductive procedure will, we believe, become immeasurably more effective, when it is guided by scientific canons.¹

Countless are the occasions when the most specious deductions prove mistaken on examination. Here is a fascinating illustration: "A most interesting and beautiful example of . . . a rhythm dependent upon external stimulation under normal conditions, but capable of becoming automatic in the absence of the wonted stimulus, or its delayed arrival beyond the accustomed time, is found in the case of the phosphorescent organisms so abundant in our seas especially in the autumn months.

"It might be supposed at first thought that these phosphorescent organisms are not observed to emit light during the day because of the presence of sunlight, and that, if taken into a dark room, such as is used for photographic purposes, they would be found to phosphoresce just as brilliantly as at night. Such is, however, not the case; not a spark can be elicited from them even by vigorous shaking, so long as there is daylight in the outer world. But if one stands by and watches in the dark room, as twilight is falling outside, although the organisms have not been exposed to light all day, one observes the little lamps light up and flash out one by one like coruscating diamonds in the darkness, till the whole dish is studded with flashing and disappearing light, a glorious sight in the darkness and stillness.

"At daybreak, the series of changes are the reverse of those witnessed at dusk; if the dish containing the organisms be observed in the dark room about an hour before sunrise, it will be seen that at first the organisms are still flashing out brilliantly, but about half an hour before sunrise, the number of flashes begins to diminish rapidly; at sunrise there are hardly any showing, and half an hour later even violent stirring will not produce a single sparkle. The most remarkable thing of all is that this regular daily phasic action is kept up for as long as fourteen days, by which time the organisms have perished in captivity. Regularly every evening the lights come out, and as regularly every morning they are extinguished, although all the intervening time the tiny living creatures have been kept in darkness.

"A similar diurnal rhythm has been observed for shorter periods in plant leaves which alter their position at day and night, when the plants have been kept in darkness." (Benjamin Moore, *op. cit.*, pp. 250—252.)

§ 198. Hypothetical deductions are common in scientific enquiries, and usually there is nothing preternatural about them. We shall supply a few examples. Einstein states: "We know

¹ An extreme example of reliance on deduction, with almost complete exclusion of induction, is to be found in Malebranche's *De la recherche de la vérité*, more especially in the latter portion of the Second Part of "De la méthode".

with great exactness that this velocity [of light] is the same for all colours, because if this were not the case, the minimum of emission would not be observed simultaneously for different colours during the eclipse of a fixed star by its dark neighbour." (*Relativity*, 1920, p. 17.) Sir William Ramsay reasoned: "If radium is disappearing, it must be continually in process of formation, else there would be none on the surface of the earth. . . . As radium is always associated with uranium, it appears not unreasonable to suppose that uranium, too, which is a radio-active element, is slowly changing into radium." (*Essays Biographical and Chemical*, p. 174.) Thorpe concluded: "Experiments made by the method of Kundt and Warburg—i.e., by determining the ratio of the specific heats at constant pressure and constant volume by the velocity of sound in the gas—prove that argon, like mercury gas, is monatomic. This of itself indicates that argon is an element, since a monatomic compound is a contradiction in terms." (*Op. cit.*, vol. 2, p. 36.) Professor Arrhenius argued: "If we calculate how much salt there is in the sea, and how much salt the rivers can supply to it in the course of the year, we arrive at the result that the quantity of salt now stored in the ocean might have been supplied in about a hundred million years." (*Worlds in the Making*, 1908, p. 42.) Similarly Lord Kelvin disturbed the peace of geologists and evolutionists by inferring from the rate at which the earth's heat radiates into space that the age of the solid earth is only about twenty million years, a deduction which subsequently had to be drastically modified owing to the discovery of radio-activity. Lord Lister cogitated thus: "If putrefaction is always due to bacterial development, this must apply as well to living as to dead tissues; hence the putrefactive changes which occur in wounds and after operations in the human subject, from which blood-poisoning so often follows, might be absolutely prevented if the injured surface could be kept free from access of the germ of decay." (H. S. Williams, *The Story of the Nineteenth Century*, 1900.) Sir Ray Lankester expresses himself as follows: "If, as seems probable, the presence of helium indicates the previous presence of radium, we have the evidence of enormous quantities of radium in the sun, for we know helium is there in vast quantity. Not only that, but inasmuch as helium has been discovered in most hot springs and in various radio-active minerals in the earth, it may be legitimately argued that no inconsiderable quantity of radium is present in the earth." (*The Kingdom of Man*, p. 46.) Lord Avebury declares: "If folded mountains are due to a diminution of the diameter of the earth, every great circle must have participated equally in the contraction." (*The Scenery of Switzerland*, 1913, pp. 481–482.) E. W. McBride remarks: "Since oxygen can only be taken into the living substance and the poisonous excreta got rid of by the process of diffusion,

it follows that living substance can never be accumulated in large masses, but can only exist in the form of small granules, or of thin plates presenting relatively large surfaces to a circumambient fluid of some kind. . . . Since life is a fire, and since this fire requires the constant diffusion of oxygen into the living substance and of carbonic acid out of it, living substance must be a fluid, since only in fluids and gases can diffusion exist." (*Zoology*, p. 20.) J. Arthur Thomson claims that "if a portion of the germ plasma of a fertilised ovum is preserved unchanged during development to form the rudiments of the reproductive cells of the new organism, and if the germ-plasma is as stable as Weismann makes out, then there is a strong probability that no variations produced in the body by use or disuse or by outside influences can be transmitted". (Article "Heredity", in *Chambers' Encyclopædia*, ed. 1908.) Edison proceeds in the same manner: "If the indentations on paper could be made to give forth again the click of the instrument, why could not the vibrations of a diaphragm be recorded and similarly reproduced?" (Edison, as quoted in *Inventors at Work*, by George Iles, 1907, p. 311.)

And here is an illustration courteously supplied to the author by Dr. Cecil Desch: "The success which attended the application of the undulatory hypothesis to the explanation of light led its supporters to follow out its consequences to their furthest limits. It was found deductively, by mathematical reasoning, that light must exert a minute pressure on a surface on which it falls. The calculated pressure was so small that its measurement appeared almost hopeless, but two very skilled investigators succeeded in devising means for measuring it, and their results have been confirmed by others. There is an interesting consequence of this. The pressure on a particle due to light is proportional to its surface. Imagine small particles exposed to the sun, in free space. They are attracted by the gravitational force of the sun, and repelled by the pressure exerted by its light. The smaller they are, the greater is their surface in proportion to their volume (or mass, if they are all alike). Hence, at a certain limit of size, attraction and repulsion will just balance one another, and still smaller particles will actually be repelled from the sun instead of being attracted by it. Now, there are spectroscopic reasons for saying that comets' tails are composed of fine dust. The repulsion of such fine particles by light falling on them explains perfectly why comets' tails always point *away* from the sun."

Perhaps the most brilliant deductions recently made are those by Einstein, resulting from his theory of relativity. From that theory he inferred that the eccentric rotary movement of the orbital ellipse of Mercury, which is 43 seconds of arc per century, was not an exceptional, but an extreme case, the corresponding amount of rotation of the other planets being simply

too small to be detected with the delicacy of observation possible at the present day. Also, he calculated the magnitude of the curvature of light rays passing the sun at grazing incidence to be 17 seconds of arc, which has been apparently confirmed by observations recorded during the solar eclipse of 29th May, 1919. Finally, Einstein inferred from his theory "a displacement of the spectral lines of light reaching us from large stars, as compared with the corresponding lines for light produced in an analogous manner terrestrially" (*op. cit.*, pp. 103–104), with what success remains yet to be seen.

§ 199. The extreme form of the deductive procedure, such as Bacon condemned, is to venture on a bold conjecture and to believe that the subsequent deductions will support or cancel it. We have already dilated on the folly and the wastefulness of this method. In scientific deduction we proceed from a genuine hypothesis and endeavour to test it by noting its implications. The first virtue, therefore, of a proper scientific hypothesis about to be treated deductively is that it should be in the form of an extremely definite statement, a statement clothed, if possible, in mathematical garb; and, consequently, the published inductive enquiry should not fail to contain such a definite statement or statements. The inductive inquirer must therefore pave the way for the deductive inquirer, and deduction, like induction, should be regarded as a scientific duty, which may not be neglected. Once the latter point is admitted, a deductive code becomes a necessity, and it is probable that this will demand that deductions, like observations and generalisations, should be "graded, comprehensive, important, numerous, full, rational and relevant, original, automatically initiated, and methodically developed".¹ By insisting, then, that the inductive process should prepare the way for the process concerned with theoretical deductions, as that should prepare the way for deductions of a practical character; that deduction is an integral component part of the scientific process of investigation; and by assimilating its methods to those of the other chief portions of scientific procedure—observation and generalisation, we round off our examination of the principal methods employed in the sciences, we resist over-emphasis or under-emphasis of any one of the principal methods, and we secure an endless chain of investigations.

§ 200. In view of the difficulties ordinarily encountered in deduction, it may seem extravagant to ask that the deductive process should be governed by rules, as suggested in the heading of this Conclusion. Yet, audacious as the proposal appears at first sight, it may, we believe, be frequently realised to a considerable extent. In asserting this, we are in a fair way of robbing the process of its mystery and magic, and of ap-

¹ For the full significance of these adjectives, see Conclusion 25.

proaching the standpoint of Francis Bacon who had the temerity of seeking, by the ladder of methodological rules,¹ to raise the mentality of the average man to the giddiest heights. To the end of proving the reasonableness of automatically initiated and methodically developed deductions, at least in certain cases, we shall examine deductively the proposition "Culture is a pan-human product".

For practical purposes, we shall assume the absolute truth of the proposition, leaving it to him who makes the deductions in the course of an enquiry to allow in each instance for the corrections necessitated by special circumstances. Our aim will be to show that by following certain methodological rules mechanically, appreciable headway may be made in rendering explicit the implications of a general proposition. Of course, thorough acquaintance with the topic of the proposition is presupposed.

The two terms of significance in the proposition are manifestly "culture" and "pan-human". Following Conclusion 19, we commence at the beginning and analyse therefore the implications of the first term, naturally in relation to the second.

1. As a first step, and in order to reduce complexity (Conclusion 20), we break up the word Culture into the principal recognised types of culture—moral, intellectual, hygienic, and æsthetic culture, but ignore, for simplicity sake, their inter-relations.

Following the simplest practicable case (Conclusion 20), and the Conclusion mentioned in the penultimate paragraph, we shall deal below with moral culture alone, and envisage in the first instance only the individual.

2. Moral culture is a pan-human product.

3. Given 2, it follows that, in identical external (*i.e.*, non-congenital) circumstances, the moral contribution of any one individual to the existing moral treasure is equal to the total moral treasure existing, divided by the number of human beings who have lived and who are living.

4. This involves that whatever differences exist in matters moral among individuals are due respectively to favourable or unfavourable external circumstances.

5. This further suggests (Conclusion 20) that the profoundest sage—a Socrates or a Buddha—and, for example, the most benighted Australian aboriginal, would, but for varying external circumstances, make the same moral contribution to the moral treasure of the world.

6. The existence of the lower extremes, mentioned in 5, again involves that the actual direct moral contribution of a Socrates or a Buddha is practically infinitesimal.

¹ "My way of discovering sciences goes far to level men's wits, and leaves but little to individual excellence, because it performs everything by the surest rules and demonstrations." (*Novum Organum*, bk. 1, 122.)

7. And this involves that the reputed moral contribution of a Socrates or a Buddha consists, for all intents and purposes, of a portion of that part of the collected store of moral wisdom which was at his disposal in his circumstances.

8. And, further, that save for the collected store, other circumstances being equal, a Socrates or a Buddha would, according to 3 and 5, exhibit a wholly inappreciable amount of moral culture, below that of the most neglected Australian aboriginal.

9. Again. Applying 8 to our day, and taking any examples of the two extremes, it would follow that, save for external circumstances, the difference between the moral culture possessed by them would be indifferent.

10. Thinking now of the realm of practice according to Conclusion 31, and for this purpose assuming ideal circumstances, in conformity with Conclusion 20, every individual might be a Socrates or a Buddha, even greatly surpassing both in moral excellence, and every individual might strive to resemble them.

11. Finally, to conclude with a definition according to Conclusion 15, from the preceding it follows that the unit of the moral contribution of an individual may be measured approximately by the moral contribution of the culturally most neglected individual of the most primitive community extant to-day or historically recorded. Etc., etc.

If we choose, we may pursue our examination by breaking up the word "moral" into the cardinal virtues Justice, Temperance, Prudence, and Courage, and proceed, as above, first, for instance, with the analysis of the term Justice.

We might then break up the word Justice, and proceed with the first constituent as above.

Etc., etc.

Inspecting now our deduced propositions, we note that we had deliberately dealt only with the individual. Following recognised classifications, we systematically extend our deductions to sex, family, class, stock, people, nation, sub-race, and race.

Culture being pan-human, we infer, then, that what we affirmed of the individual in regard to his moral contribution, holds, *mutatis mutandis*, of sexes, families, classes, stocks, peoples, nations, and races. That is, each has congenitally the same status as its congeners.

Summing up, according to Conclusion 34, we may state that, save for varying external circumstances, the moral, intellectual, hygienic, æsthetic, and other cultural contributions of any one individual, sex, family, class, stock, people, nation, sub-race, and race are equal to those of any other individual, sex, family, class, stock, people, nation, sub-race, and race, and the highest conceivable condition of perfection is attainable by all, and should be aimed at both individually and collectively, in conformity with varying external circumstances.

Etc., etc., with the eleven points.

Examining our deduced propositions again, we notice that external circumstances play a vital part in the moral position occupied by an individual, etc., for if moral culture is a pan-human product, it must be absorbed from the environment through some form of learning. These circumstances, we may broadly define, following a classification already at hand, as (a) individual circumstances, (b) special social circumstances (*e. g.*, the section of society specially interested in moral culture), (c) general social circumstances, and (d) special and general contemporary moral and social circumstances insofar as they affect the individual, etc., directly or indirectly.

Should we be desirous of a fuller analysis of the factor of circumstance, we bring to our aid the ampler list of the environmental conditions contained in § 139.

1. To understand the moral position occupied by an individual, etc., we should study the respective cultural effects of the above conditions.

2. In proportion as the external circumstances are improved or the reverse, so the moral position occupied by an individual, etc., is improved or the reverse.

3. If we desire, and if it is our duty, to raise the moral position occupied by an individual, etc., we should improve the apposite external circumstances.

Having fairly exhausted the implications of the term "culture", we turn to the term "pan-human", and develop the implications as in the former case.

From our above examination we conclude that just as observation and generalisation can be methodically pursued, so may deduction. There is no necessity to wait for inspiration, for accident, or for need, before deducing the implications of a proposition, and when accident or need raises a problem connected with deduction, the new methodology requires that the investigation shall be conducted, as far as possible, in agreement with far-reaching canons which ensure the most satisfactory and most exhaustive treatment—a treatment which, like that involved in generalisation, leads to deductions which are graded, comprehensive, important, numerous, full, rational and relevant, original, automatically initiated, and methodically developed.

§ 201. Deduction also occupies an important place in interpreting facts. The physician may admonish his patient: "Do not cough more than you can help." Such an injunction may serve its immediate purpose. If, however, he said, "Do not encourage coughing; it may develop into a habit", his patient would be helped to infer how he should act whenever he suffered from a cough. If, finally, the physician had declared: "Actions tend to become habits; gently resist the tendency to cough", his patient would possess a guide for life in countless contingencies. The superiority of deduction for explanatory

needs, especially when the proposition is a comprehensive one, is therefore manifest. To understand, accordingly, the principles on which an instrument, a machine, a living body, or an ideational complex is constructed, is to be in a position to explain numerous facts which may otherwise each require a separate explanation.¹ Hence with scientific advance it becomes more and more appropriate to explain new facts by old facts instead of seeking in each case for a particular and isolated explanation.

§ 202. Generalisation and deduction form, then, essentially one process, consisting in the systematic search for ordered similarities, only that in the former connection the statement reached is more comprehensive than the one which formed our point of departure and that we do not necessarily start from a definite statement, whereas in deduction we set out necessarily with a definite statement and our conclusion has a narrower basis than this statement has. Indeed, deduction, we perceive now, is intimately related to generalisation, because to discover the implications of a leading generalisation is tantamount to discovering certain classes of facts in the course of the generalising process. We might speak of deduction as inverted generalisation. Both processes tend, by means of hypotheses, to extend the field of truth.

The need for verification (Conclusion 29) is, of course, imperative in deductive procedure, and general statements, in the form of terse and luminous definitions, should be aimed at here as in rounding off an inductive enquiry. (Conclusion 30.)

SECTION XXVII.—APPLICATION.

CONCLUSION 32.

Need of Drawing Practical Deductions.

§ 203. In § 2 we sought to establish that the whole of existence forms a unity, and that the scientific process cannot be therefore restricted to what are styled physical and abstract truths. There we showed how comprehensive had become the sphere of applied science, and how scientific workers have from time immemorial consecrated part of their energies to making life more tolerable through those identical means whereby they extended the sphere of theoretical truth.

In this Section we desire to advance a step beyond. We wish to submit that the scientific process is also one, and that accordingly it is only complete when fair attention has been

¹For this reason Bacon never tired of extolling the importance of Forms or natural laws. According to Alois Riehl, "Logik und Erkenntnistheorie", in *Systematische Philosophie*, 1907, Galileo aimed, not at induction or deduction, but at establishing laws.

paid to the more intimate aspects of life. Otherwise, the truth we have attained to is only a partial one and arbitrary to boot. In all the sociological sciences the connection between theoretical and practical deduction is so close that in any sociological investigation purporting to be comprehensive it would argue a grave dereliction of scientific duty to pass cavalier-like over what are called practical problems. Given that the deductive enquiry is virtually completed on the theoretical side, it should automatically open on the practical side. Thus the statistician, the economist, the jurist, the historian, the philologist, the psychologist, the anthropologist, the ethnologist, the educationist, the moralist, the religious and æsthetic thinker, should conceive it as part and parcel of their duty to begin with precisely defining their task, proceed to observation, generalisation, verification, interim definition, and deduction, and pass beyond to application. In reality, as Conclusion 2 implies, the problem of drawing practical deductions should be a living one for the inquirer from the introductory to the terminal stages of his investigation, especially now that the facts of the practical life have been classified to a notable extent and that the life of practice is becoming more and more organised and organisable.

The biological and physical sciences occupy an analogous position. The varied problems of agriculture, frugiculture, horticulture, arboriculture, dairy farming, stock rearing, and fisheries; of hygiene (general, industrial, school, etc.), dietetics, appropriate clothing, and sanitation; of the combating of infectious and other diseases; and of insect pests, dangerous animals, and premature old age and reckless living, should be ever pressing for solution in the mind of the biologist. The physicist and chemist have similar tasks before them—the physicist's rays, compass, and knowledge of mechanics, for instance, are of incalculable import, and so are his discoveries of novel or improved material energies and raw materials, or his contributions to the ventilation, lighting, heating, acoustics, cleaning, health, design, safety, and soundness of every type of building and boat, whilst the chemist's contributions in regard to manufactures, agriculture, and medicine are invaluable. The meteorologist may also help mankind to produce and avert, or at least predict, rainfall, atmospheric humidity, heat, stronger or weaker air currents, and clouds, whilst the astronomer, the geographer, the geologist, the mineralogist, the seismologist, the oceanographer, and all other types of scientists—not least the mathematician—may equally render priceless service by extending and systematising the realm of practical truth.

For instance, psychologists and physiologists have been for a generation engaged in inventions of a practical character relating to industry. The energy expended in a particular task has been examined by means of the dynamometer, the fatigue experienced by the ergograph, the pain felt by the algesimeter, the vital

capacity by the spirometer, the speed by the stop-watch or the film, and the relations subsisting between these diverse factors have also been studied. Yoked to the "scientific management" movement, these experiments may confer incalculable economic benefits on the community. In addition to this, psychological and physiological examinations of individuals, more particularly on the side of nervous and sensory conditions, and of types of mental association, have already been instrumental in fitting square men into square holes and round men into round holes.

In short, he who examines a phenomenon from every possible theoretical point of view, will be best able, if trained, to recognise also its value for the furtherance of the practical uplift and organisation of mankind. Just as we are bound to protest against haphazard enquiries, against petty or too extensive investigations, and against unsystematic procedure or only attending to observation, generalisation, or deduction; so it is our office as methodologists to plead that it is unmethodological, now that science and the life of practice are so highly developed, to neglect drawing practical conclusions in the proper place and in due course.

Needless to state, he who is engaged in an enquiry of a quasi-practical nature ought likewise to do his best to augment as far as possible the sphere of quasi-theoretic truth.

§ 204. The following quotation relating to the practical aspect of biology well illustrates the interdependence of the theoretical and the practical life:

"Our knowledge of animals, like the child's, obviously arises with their chase; and that of the aspects and properties of plants, wholesome and poisonous, perhaps even medicinal, with the hungry search for roots and berries. The evolution through higher social states finds its reflection in widening zoological and botanical folklore, and the developed agricultural conditions of civilised life not only admit of the increasing and systematising of our knowledge, but even at length contribute valuable conceptions, like that of selective breeding, of which Darwin has made such especial use. The recent contributions of biology to the arts of life have been of course primarily associated with the advance of medical treatment; hence the popular and even medical conception of the botanist is still based upon the traditional one of the herboriser in quest of specific remedies. The increase of food-supply, through pisciculture and breeding, and through the destruction of the enemies of useful species, is an application of more recent but widening growth; in fact those applications of our knowledge of cryptogamic pests which have especially culminated in the labours of Lister and Pasteur, at present furnish the stock illustration of the applicabilities of pure biology. New ideas are also germinating; thus speculation is busy, *e.g.*, with schemes of artificial human selection; while rapid progress is being made in the transition from detailed medicine to wholesale hygiene—*i.e.*, beyond the mere application of specific remedies to morbid individual variations, and towards a progressive and harmonious re-organisation of the functions and environments which are afforded by the human hive or city to its individuals . . .

"In tracing the progress of biology, we are simply following the reflection of the changing lights cast upon the organic world by each prevailing mode of general thought and social life. In a word, the evolution of biology forms part of the general social evolution; the science is no completed

body of truth, but merely such portion of it as our stage of social progress enables us to see. Else the rise of science from art would be little more than an almost prehistoric process, instead of being still and continually going on. Innumerable instances, large and small, might be given of this; thus, the classificatory doctrine of the 'échelle des êtres' due to the naturalist Bonnet, is far more than a mere detail of the biographical history of zoology; for the conception of an unbroken series of beings ascending in regular gradations from the lowest up to the highest is obviously the projection upon nature of that established ecclesiastical and social hierarchy in which the good abbé's mind was formed. Again, taking a larger instance, the substitution of Darwin for Paley as the chief interpreter of the order of nature is currently regarded as the displacement of an anthropomorphic view by a purely scientific one: a little reflection, however, will show, that what has actually happened has been merely the replacement of the anthropomorphism of the eighteenth century by that of the nineteenth. For the place vacated by Paley's theological and metaphysical explanation has simply been occupied by that suggested to Darwin and Wallace by Malthus in terms of the prevalent severity of industrial competition, and those phenomena of struggle for existence which the light of contemporary economic theory has enabled us to discern, have thus come to be temporarily exalted into a complete explanation of organic progress.

"Finally, the division of labour having become fully established in industrial practice, and recognised in economic theory by Adam Smith, it was frankly borrowed for biological application by Milne-Edwards, almost a couple of generations later, with fruitful results. This industrial development has indeed not only given us our present clear conception of separate organic functions, where an earlier school could see only their general resultant as 'temperament', but it has also determined the prevalent intensity of scientific specialism within artificially restricted fields. Hence too, the extreme specialist's not infrequent loss, if not indeed denial, of definite responsibility to the science as a whole, and still more to that larger progress of which it forms a part is simply the equivalent of that loss of conscious relation both to the special task and to its general bearings, from which at present the labourer also so frequently suffers. . . .

"The manifold importance of biology in education is seen not only in its practical applications in the arts and in the study of medicine, but as a potent agency of culture, and as preliminary to psychological and social studies." (Patrick Geddes, Article "Biology", in *Chambers' Encyclopædia*, 1908.) (See also G. Sarton, "L'Histoire de la science", in *Isis*, March, 1913; T. B. Robertson, "The Historical Continuity of Science", in the *Scientific Monthly*, October, 1916; and Arthur Dendy (editor), *Animal Life and Human Progress*, 1919.)

Nor should Bacon's pregnant rule be overlooked that when we have once established a fact, we should determine how it is, and may conveniently be, produced or reproduced, or destroyed if need be.

§ 205. We will venture on one extended illustration in regard to the application of science to practice. At the close of the eighteenth century a French scientific commission elaborated the metric system, a system of measurement which is not only signally superior to the "natural", or rather casually developed, modes of measuring then or now in vogue, but which is irresistibly spreading over the globe. We suggest that philologists might perform the same priceless service for language, even though a distinguished litterateur, Viscount Morley, should dilate on "how immutably the tongues of leading stocks in the world seem to have struck their roots".

(*Notes on Politics and History*, 1913, p. 92.) Indeed, according to our methodological criterion, it is incumbent on the philologist to concern himself with the practical as well as with the theoretical aspects of his studies. Methodologically, he has no option in this matter, and no doubt these practical investigations will beneficially react on his theoretical views.

With the metric system as his model, we shall assume that he will desire to re-fashion language in its entirety, in conformity with ideals not less exacting than those which inspired the French commission adverted to. Familiar with the structure of a multiplicity of tongues, and conversant with everything material which has been written on this topic, he will, in a generalised and rationalised form, incorporate from those sources whatever is of permanent value. Moreover, true to the methodological ideal, he will devote his whole life to this enterprise, seek the counsel and co-operation of the most competent authorities, and succeed, we trust, in inducing some international academy to assume the main responsibility for the inauguration and execution of the monumental task. Probably the goal can only be reached by generations of scholars collaborating. If so, the sooner the work is undertaken, the better.

In the circumstances it will not be expected that we shall here attempt more than the faintest adumbration of this project. That is, in all important respects we shall only be able to touch on the methodological aspects, and, even in this connection, much will be necessarily left unsaid or obscure because of the present writer's painfully deficient philological equipment. Only this should be added prefatorily that once an approximately satisfactory system is evolved, temporary and partial applications may be made relating to existing languages, whilst the very construction or existence of a scientifically elaborated medium of lingual communication—first naturally employed in scientific work—will indicate the path of lingual advance and encourage its being trodden.

1. First, a few words anent the sounds of the language. In this respect economy and euphony would be aimed at. Each character would represent one distinctive uncompounded consonantal or vowel sound, and wealth of elementary sounds would be favoured, rather than reducing their number or keeping them at a minimum. Approximately forty uncompounded sounds are met with in European languages, perhaps twenty consonants and twenty vowels. Assuming them to be expressed in visible characters on the principle illustrated below, appreciably more than half the time at present occupied in *mère* writing would be saved, whilst a single alphabet could serve for writing, printing, and other purposes. Capital letters would be only employed initially, in the case of proper nouns, and for emphasis and ornamentation. These capitals might be

formed by simply commencing the upward stroke of a letter from below the writing line, saving thus a separate series of alphabetic outlines. Abbreviations of certain frequently recurring words and syllables might enable ordinary writing to proceed at, perhaps, four to five times the present speed. This is no indifferent consideration, for the handmaid of thought should not fall far behind deliberate thought itself. Here is such an alphabet:—

- (1) rotundity, rose; (2) fallow, mad; (3) fun, far; (4) fill, feel; (5) fell; fail; (6) full, fool; (7) falter, fall; (8) le, cœur; (9) Fülle, fühlen; (10) vain, fain; (11) gain, cane; (12) bane, pain; (13) sing, sont; (14) licht, lachen; (15) leisure, shun; (16) there, think; (17) (unused); (18) (unused); (19) do, to; (20) as, so; (21) lot, roll; (22) yes, we; (23) net, met; (24) he; (24a) jeer, cheer; (24b) sigh, joy, now; (25) Knowledge is Power.

The systematic order and the quality, as well as the time value and desirable time variations, of primary sounds, would be ascertained and fixed by phonograph, and preserved for reference in record offices as are the metrical standards.

The consonantal and vowel compounds would be constructed on the same basis of economy and euphony, eschewing as far as practicable all cumbrous combinations and favouring those which are mellifluous or characterful.

2. In the framing of the letters into words the above constructive principles would be also followed.

The present practice of only encouraging euphonious combinations would be continued, but on a strictly systematised basis and independently of conventional standards. This might be, perhaps, effectually aided by arranging that root words should begin with a vowel, and be divided from prefixes and postfixes by a *y* and *w* respectively. Prefixes would consist of a consonant followed or not by a vowel, and postfixes of a vowel followed or not by a consonant.

3. For the reasons already enumerated in 1, accentuation of syllables would be preserved and regularised. Perhaps every second, fourth, etc., syllable would be accentuated. Perchance on the same account accents might be subdivided into weak and strong ones, the strong syllable falling invariably on the second syllable, the weaker on the fourth, etc. Furthermore, accentuation, as in English, would be extended to the words composing a sentence, *e.g.*, in “a very large house” the word accent steadily rises, enabling the comparatively greater emphasis to be placed on the comparatively more important word in a sentence, and rendering the language both less monotonous and more intellectual. Lastly, accentuation for the sake of particular emphasis, would be permissible, as in “*that* man!”

Thus far we might be said to have concerned ourselves with the æsthetic and with the crudely elementary aspects of the problem, for the fundamental question in respect of a language which professes to be constructed on a scientific basis is (*a*) how the words can be shaped so as to possess a rigidly fixed meaning, and (*b*) how we can arrange that that meaning shall reflect scientific facts and the scientific spirit. Unless we are tolerably successful in this phase of our enterprise, we may be said to have broadly failed. At present, so far as the signification of the constituents of a term are concerned, *cat* might mean, for instance, *dog* or *mountain*, and therefore the term *cat* provides us with no inner clue to its connotation. Here, then, our radical reform must have its starting point. Every letter, like every cardinal number in arithmetic, should have a definite meaning¹ and one exhibiting a scientific character. In this matter the signification of a word would consist of the sum of significations of the separate letters arranged in a certain order. The unit of significant language, that is, would be the letter and not the word.

In consonance with this principle the scientific alphabet might be assumed to be constructed of numbers having cardinal and ordinal implications, and thus satisfy mathematical requirements. The ten short vowels, in their *proper phonetic order*, would represent, or rather be, the figures 1 to 0, and for convenience, the corresponding long vowels would stand for 11 to 20. (In the spoken language, when used for arithmetical purposes, the decimal units above the first—hundred, thousand, etc.—would be each represented by a consonant in a series corresponding to the vowels, pronounced with the corresponding vowel which

¹ In this connection note the tacitly recognised common meaning underlying so many words beginning with *gl*, most of them suggestive of light: glabrate, glacial, glaxis, glad, glade, gladiator, gladiolus, glair, glaive, glamour, glance, gland, glanders, glare, glass, glaze, gleam, glean, glebe, glee, glen, glibe, glide, glim, glimmer, glimpse, glint, glissade, glisten, glitter, gloaming, gloat, globe, glomerate, gloom, glory, gloss, glottis, glove, glow, gloze, glucose, glue, glum, glut, gluten, glycerin, glyptic. (See, however, 4.)

precedes it.) These numbers, especially from 1 to 20, and even 1 to 400, would enable us, according to the context, to express differences of degree and number as well as difference in order of fact. Moreover, the ordinal place of a letter in a word would also convey an ordinal meaning. All this would hold *mutatis mutandis* of consonants whose root meanings would be identical with those of the vowels.

4. The twenty vowels and the twenty consonants would be arranged in accordance with a strict phonetic scheme and fixed by phonograph. This accomplished, the successive vowels would have assigned to them a meaning corresponding to the, say, twenty hierarchically ordered categories of facts, and the succession of consonants would possess the same signification. For instance, the meaning implied in *a*—if *a* be the first letter—would be a universal one, and accordingly we should have, for example, *at* ethereology, *ag* molecular physics, molar physics . . . to biology, morals, art, etc. We may further assume all knowledge to be divided into kingdom, phylum, class, order, family, genus, species, variety, and individual. Assume that a root word consists, unabbreviated, of eight letters. Then the number and places of the letters will convey the inherent meaning. Should there be more than twenty of a category, the vowel or consonant is doubled to express the number, up to 20 times 20, or four hundred. However, the need for double consonants or vowels would seldom occur. So far as the meaning of the letters composing it are concerned, the word “mammal” in the language of to-day is a bare jumble of sounds. In the scientific language it would consist, say, of the letters *e* (animal), *b* (nth phylum), *o* (mth class), or *ebo*. Or if we thought of a tiger, we would, perhaps, have the word *ebonimu*, indicating by its successive letters kingdom, phylum, class, order, family, genus, and species. Millions of significant terms could be framed in this wise, multitudes of them consisting of one syllable. Granted ingenuity equal to the needs of the case—which is assuming much, we admit—and a language of a scientific character may be constructed, a language where the letters of the alphabet reflect the scientifically determined categories of facts. Such a language, too, would not only image the sciences; it would compel wide and sound information, clear and scientific thinking, lucid and terse expression, and would be readily acquired, and difficult to forget, to misunderstand, or to pervert. Nothing short of such a result could satisfy the methodologist. Science is already far advanced, and a scientific language has therefore become possible; but if it be contended that allowance should be made for the correction of errors, the reply is that for this also systematic provision might be made. However, it should be remembered that, to judge by the last hundred years, changes in language proceed with extreme slowness. Perhaps, too, every century

a Commission could re-examine the language and bring it up to date.

Needless to state, each radicle would have its significance definitely determined and retain it until formally altered.

5. Each primary word should be automatically capable of being employed, in a duly modified form, as any part of speech. Here is a paradigm:—*Noun*: internment, interner, internness, internee (also special words for that which interns and that which is interned—general, masculine, and feminine; also selected words for objects and persons professionally or frequently interning or being interned, as filter or explorer), internability, internness, internivity, internity, internage, internium, internism, internation, etc.; *verb*: to intern, interned, interning (also internify, internesce, etc.); *adjective*: internal (internal, internable, internive, etc.), internative, interniform, interniferous, etc.; *adverb*: internally (also internerally, etc.). Naturally only one modification would exist for each form of speech: *a*, for instance, as the sole adjectival form, and we should say, for instance, I, thou, he, we, you, they, *have*. Similarly, the free and common use of all parts of speech and of all modifications would be encouraged, in accordance with methodological requirements. Tenses would, of course, be formed by a single unmodifiable postfix for each tense. Each modification would exhibit its signification in the letters whereof it is composed—*e.g.*, internal-like.

6. Four hundred prefixes and as many postfixes could be created to express the modifications which root words are capable of. A word would be known to have a prefix if it commenced with a consonant, and recognised as having a postfix if a *w* occurred therein, all letters before a *y* being a part of prefixes and all letters after the *w* of postfixes. Modifiers representing the categories and the principal human departments—health, morals, intelligence, beauty, economics, politics, happiness—would, of course, be introduced, and at once enrich and simplify the vocabulary. Already such prefixes as *mis* (misunderstand) and *mal* (maltreat), for instance, express intellectual and moral deficiencies respectively, and what is therefore needed is a full development of present right tendencies in language. Nor should various other forms of prefixes be forgotten, as, for instance, negative: in(curable); privative: a(chromatic); opposite: un(lock); separation: dis(jointed); and so forth. These modifiers would retain their form and meaning integrally in all circumstances, and be applied, as required, to all root words and their combinations, as unindecomposability. It would be understood that the letters constituting the prefixes would be one in form and meaning with the radicles whence they are derived.

Similarly nouns would be freely joined, as window frame, detention house, child cruelty prevention association (instead

of association for the prevention of cruelty to children). Innumerable cumbersome and uncouth sentences would be thus avoided and a wide range of expression secured, as in German.

7. Words should be connected in sentences in conformity with a definite and simple order, as "This represents an altogether correct version of what transpired at the conference yesterday"—not as in Latin or German where emphasis or grammar sunder what should be united. Such a determinate order would conduce to clarity, and appreciably reduce the time required for learning how to express oneself appropriately.

8. The present system of punctuation should be, perhaps, supplemented, especially so far as the comma is concerned, and strictly regulated. Fine distinctions are to-day sometimes difficult to express because of the comparative poverty of our system of punctuation. In "*ethics or the science of conduct*" and "*ethics or psychology*", for instance, where the *or* suggests an alternative expression in the first case and a disjunction in the second, the difficulty might be surmounted by finer punctuation, or by having two words, an alternative and a disjunctive, instead of one *or*. Abundant punctuation should be promoted, as well as the habitual and standardised use of all the signs.

9. The problem of the length of sentences should receive attention and, within the limits of clarity, theme, and necessity, the fullest freedom and variety should be fostered in this connection in order to satisfy æsthetic and special demands.

10. Studious care should be taken to satisfy methodological requirements. Assuming that the root words express only general and positive facts, such as *size* and *goodness*, and not modifications, such as *smallness* and *badness*, a uniform arithmetical method of degrees of modification would be introduced. This might be based on the principle that ordinary discourse should demand, say, seventeen divisions, of which five—1, 5, 9, 13, 17—would be in common use, whilst more discriminating speech would tend to employ all the seventeen divisions. (One, nine, and seventeen are chosen as yielding a beginning, middle, and end, and a fair number of intermediate divisions; and we postulate 1 as the lowest degree.) Where negatives (good-bad) or extremes (top-bottom) occur, the seventeen divisions would be naturally employed, 9 forming the point of indifference. Countless modifying words would thus become redundant; the liability to depreciation and fluctuation in the modifiers would be circumvented; unlimited delicacy and variation in expression would be attainable; and a high minimum of accuracy and clarity would be exacted. Already measurement of time, number, distance, etc., is peremptorily demanded wherever it is feasible by those of a reflective cast of mind, and speech where vagueness is shunned and numerical factors are frequently introduced, is not uncommon. Thus "this is

perceptibly, distinctly, markedly, considerably, conspicuously, substantially, strikingly, remarkably, completely true", would become "this is one, two, three, four, five, six, seven, eight, nine true", or if false be included, we reach the series 1 to 17, and so with all modifications. Similarly, "one (to seventeen) frequently", "one (to seventeen) altitude mountain", etc. Language would probably gain immeasurably by such a method, and emotions would attach themselves to these numbers as to words.

11. The art of the poet and the orator would be universalised. Terms and expressions possessing restricted meanings would be systematically transferred to new subjects or generalised. In this manner terms and expressions relating to law, religion, commerce, the arts and sciences, etc., would be, though controlled, systematically employed outside these realms whenever convenient. Terms and expressions would be thus indefinitely multiplied; the latest of these would be fully exploited; older terms and expressions would not impose on us; and language would be incomparably fresher, breezier, and more beautiful.

12. Lastly. Instead, as is now the case, of fortuitously collecting a poor and corrupt stock of words, a vast treasure of unequivocal and vivid terms, composed of a few root characters and positional meanings, would be deliberately learned and appreciated. In this way just and delicate discrimination generally—and specifically in connection with the master subjects: morals, æsthetics, methodology, truth, civics, economics, health, and happiness—would be acquired by the child and adolescent both practically and theoretically. Men and women would systematically learn their philological, as they systematically learn their metric, system. Each root and affix would possess a fixed meaning and that meaning everybody would be acquainted with and freely employ. Language would be a living whole where every part is alive, and is related to all other parts, and not a body of words mostly unconnected with one another, capriciously changing, frequently meaningless in themselves, and living isolated, squalid, and short lives. This language would naturally tend to be the universal language, as the metrical system is tending to be the universal system of measurement, and as the latter is capable of improvement—perhaps into a duodecimal system—so our scientific language would be perfected with the ages by regularly recurring periodical revisions. It is inconceivable that mankind will continue much longer to be satisfied with acquiring in a haphazard fashion a cumbrously complex and exasperatingly obscure and confusing language to serve as the principal medium of communication with our fellows and chief means of communion with ourselves.

SECTION XXVIII.—CLASSIFICATION.

CONCLUSION 33.

Need of Judicious Classification.

§ 206. Language is a vast repository of classifications. Let us analyse an imaginary example. Suppose the vague idea of good enters the primitive mind. Then it is an important step in advance for that mind to evolve the idea of not-good or bad. The primitive man makes headway, again, by conceiving the individual good as becoming and ceasing, and by discriminating in two directions, namely in relation to quality and quantity—very good and very bad; and better, best; worse, worst. Having reached a higher stage, he then refines the *very* into (say) imperceptibly, just perceptibly, perceptibly, slightly, passably, fairly, moderately, appreciably, distinctly, considerably, conspicuously, substantially, almost completely, completely, absolutely, extremely, and the *good* into countless virtues and duties, *e.g.*, kindness, honesty, uprightness, truthfulness, purity, self-control. He further subdivides each of these subsidiary classes in an analogous manner, and the adjectives he enriches by prefixing to them a series of delicately discriminating adverbs.

Particulars tend thus progressively to become generals and facts become more or less coherently ranged into classes. Thus the early Greeks adopted a fourfold classification of the multitude of virtues into Justice, Temperance, Courage, and Prudence; St. Paul preached the three graces Faith, Hope, and Love; and the French at the time of their Great Revolution introduced the inspiring patriotic motto Liberty, Fraternity, and Equality. We may also imagine that almost simultaneously with the development of the confused conception of the good, the ideas of the true and the beautiful struggled into being, and, accordingly, that after æons of development men select the phrase the Good, the True, and the Beautiful, as most fitly expressing what man most deeply aspires to, adding later to this trio, the Hygienic. In this way more or less discriminative analysis proceeds historically side by side with more or less discriminative classification till we obtain the highest or *summum genus*, as Being and Action, on the one hand, and the lowest, or *infima species*, such as electrical and arithmetical unit, on the other. Not until, however, the sciences emerge from the incipient stage, and a rudimentary methodology appears on the scene, is there a consistent attempt at rigid classification or division on the basis of exhaustive pan-human enquiries and tests. For this reason classification in daily life is as common as it is tentative in character, and on the same account the last word of methodology may probably be the gradual reconstruction of language on a strictly methodological foundation involving a comprehensive classification.

This reconstruction commenced, in essence, long ago. In antiquity and in the Middle Ages, where consistency constituted the ideal of sound thinking, nomenclatures and terminologies were developed in connection with diverse subjects: the special names connected with logics and with rhetoric may be cited in illustration. With the development of the sciences, progress was hastened in this direction. We have the early example of botany, where a luxurious nomenclature and terminology came into being. Chemistry can also boast of having built a wall around its preserve, saving its terms from pollution by the profane multitude. Other sciences have striven more or less successfully to achieve the same end, seeking refuge wherever possible in mathematical terms, symbols, and formulæ. Deficiencies in language, difficulties experienced in unequivocally expressing distinctions without circumlocution, are among the most formidable obstacles to progress in science. An invaluable service would be therefore rendered to science and its popularisation if some learned international body occupied itself with the project of how to design stable and appropriate nomenclatures and terminologies on a general and a scientific basis. In this attempt, the secret of a scientific language, which we sought in the preceding Conclusion, might possibly be discovered.¹

The advantage is patent of classifying stars—according to their brightness—into sixteen magnitudes, or the force of the wind into twelve magnitudes: from 1—a light air, to 12—a hurricane; the chemical elements according to their atomic weights; living beings into kingdom, phylum, class, order, family, genus, species, variety, and individual; the metabolism of life into anabolism and katabolism; the problems of life into function and environment; organisms into systems of organs, organs, tissues, cells, and protoplasm; plants into Thallophyte, Bryophyte, Pteridophyte, Gymnosperms, and Angiosperms; vertebrates into fishes, amphibians, reptiles, birds, and mammals; foods into proteins, fats, carbohydrates, vitamins, mineral matters, water, and oxygen; languages into isolating, agglutinative,

¹ A supplementary dictionary, where the words are divided into groups conformably to their signification, should be of inestimable value in illuminating the nature of language and in outlining how it may be extensively rationalised and developed. Of course, more than one tongue ought to be studied in this way. Even now, however, much might be accomplished in developing the intellectual powers by (a) training the young to the intelligent every day use of the substance of the dictionary, and (b) thoroughly habituating them to the frequent and matter-of-fact employment of such terms as judgment, balance, discernment, perspicacity, penetration, clarity, discrimination, sagacity, circumspection, caution, prudence, restraint, vigilance, heedfulness, correctness, exactitude, precision, tentativeness, diffidence, deference, moderation, reserve, discretion, considerateness, etc., as well as to methodological terms and constant recourse to measurement generally. This educational method might be advantageously extended to the principal terms employed in practice in connection with the cultural list referred to in § 1.

and inflectional or holophrastic and analytic; and the wealth of human culture into departments relating to language, transport, etc.

In practical activities classification has a special and important part to play, for, having classified, we are enabled to separate objects into groups. The grouping we may then utilise for the elimination of faulty and superfluous groups, and for the formulation of maximum number of standards, methods, tools, machinery, material energies, and establishments. For this reason, efficiency "engineers" regard classification as an indispensable means for attaining their goal.

§ 207. Classification may be, further, conceived as definiteness in arranging the final results of an enquiry. At a glance we can then perceive, as in a well-constructed book, the skeleton which forms the support of the general argument and which betokens its harmony and its compactness. Without a proper classification of the results, without divisions and headings, we are in danger of surmising that our conceptions are translucent when they are nearly opaque, and in leaving others in doubt concerning the precise results which we have obtained. In this connection we will examine a concrete example of classification, namely this treatise.

At first the volume was divided into four parts, Part III being sub-divided into several Sub-Parts. Eventually a new classification into two Books—Theory and Practice—was introduced, the Sub-Parts becoming Parts. This furnished a more useful division.

Originally, in starting the book, concrete processes of thought were examined, and rough notes were kept of the observations. Later, the notes were consolidated under more and more convenient headings. Some of these headings were socially determined—such as Observation, Generalisation, Deduction. Concurrently numerous observations were made which were less amenable to classification to begin with, *e.g.*, those in Part IV. The headings in Part II equally suggested themselves to some extent at haphazard.

"Preliminary Considerations" manifestly had to be placed first, and the order of the Considerations, once these were arrived at, were, broadly speaking, decided from the very commencement. "The Problem" also had a predetermined position, because of its logical place in the body of the work. Its introductory Section necessarily occupied its present place originally. The succession of the four Sections which followed this one, was determined by the crescendo, from completest ignorance to completest knowledge—infant and child, uneducated, educated, and man of genius. Not inappropriately this was succeeded by the "Progress of Methodological Theory". Assuming the subject exhausted, the "Conclusion" follows, and this should be so methodologically with every Part.

In Part II a logical order could be followed, as the processes considered formed practically a time or order series, and this was naturally done.

Part III had necessarily to precede Part IV, and to open Book II. Part IV consisted of all the practical matter of a preparatory or ancillary character. Of course, this matter was placed in Part IV, only after mature reflection as to its proper place in the scheme of the work. Even then the order was difficult to ascertain in several cases, and the classification no doubt still leaves something to be desired. Nevertheless repeatedly attempts were made to classify the material in such a manner that the Conclusions should at least appear to succeed each other logically.

Part V formed the crux of the problem in classification. In arranging the Conclusions in this Part in a rigid chronological order, there was not only a gain for the reader, but for the author. The latter could closely scrutinise the order he followed, and interpolate missing links which non-temporal considerations had not suggested. Thus a comparatively rounded result was obtained, classification rationalising the methodological process as a whole.

This very time order helped to focus the conception of finding an inherent connection between the successive Sections of Part V. Hence the final arrangement was reached, whereby the whole methodological process of enquiry was conceived as a single act, one part of the process following another necessarily from the commencement until the terminating Conclusion was reached. This ensured that an investigation could be only considered as complete and consummated when in an enquiry the whole series of Conclusions, in their particular order, were respected. Observation, Generalisation, Deduction, etc., were now no longer independent units, but links in a time chain.

Of course, ideally speaking, the whole of the working Conclusions ought to have been deducible in their precise order from a single methodological principle; but that the author felt he must leave to future research.

This examination of a concrete case illustrates the diversified virtues of a good classification—aiding the author to arrive at new truths and to clarify his mind; helping his readers by avoiding unnecessary confusion, by assisting correct and ready apprehension, and by compressing multitudinous details into a very few terms; and, lastly, leading to the permanent enrichment of the treasure of human knowledge by the establishment of far-reaching similarities and of radical differentiae among a certain class of phenomena.

Or, to express our results more definitely. Having completed some extensive enquiry, we seek to classify the facts under the fewest divisions practicable, connecting them as closely as circumstances permit. Each of these divisions, again, has divisions subordinated to it—also well articulated. Sir Ray

Lankester's classification of animals in the *Encyclopædia Britannica* (11th edition) may be taken as an illustration in this respect. From an ideal viewpoint the classification should omit nothing relevant, include nothing irrelevant, and each class should be rigorously separated from every other. In practice, however, this is frequently impossible, and the man of science has therefore to content himself with a resolute attempt to approach his ideal of classification, leaving it to a succession of inquirers and scholars finally to fulfil abstract methodological requirements. However, just as tentative classification should be resorted to almost from the beginning of the enquiry, especially when the Interim Statement is being reached, so the ultimate step should be to find a higher class under which our classes can be ranged, connecting in this way our enquiry with others which have preceded it. Lastly, it should be noted that, as a broad rule, intimate acquaintance with a subject already involves a fairly advanced stage of classification, and that the latter process is dependent thereon. It is rarely that purely logical considerations account for a classification. Where this seems to be the case, it represents usually either a superficial classification or one borrowed from another subject.

§ 208. It is to be expected that this treatise should suggest how the aggregations of knowledge man has accumulated to our day may be conveniently arranged, or rather re-arranged. The scheme propounded here is neither an abstruse one nor very novel. We naturally place at the head the most comprehensive science, that concerned with the Cosmos or All, *Cosmology*. Next, pursuing again evident lines of cleavage, we place all inanimate nature, under *Physics*; all life and connected individual intelligence, under *Biology*; and the remainder, pan-human, or species-produced, culture, under *Specio-Psychics*. Each of these divisions is again developed not only along conventional lines, but with the object of embracing the totality of human life and activity, while the subdivisions following the four principal divisions, suggest how our detailed knowledge may be tentatively correlated and unified.¹

¹ The following works or essays may be consulted with advantage in connection with the problem of the classification of the sciences:—

André-Marie Ampère, *Essai sur la philosophie des sciences*, 1834-1843.

Jeremy Bentham, *Chrestomathia*, Part II, 1817.

Auguste Comte, *Cours de philosophie positive*, vol. 1, Leçon II.

M. Cournot, *De l'enchaînement des idées fondamentales dans les sciences et dans l'histoire*, 2 vols., 1861.

R. Flint, *Philosophy as Scientia Scientiarum*, 1904.

Edmond Goblot, *Essai sur la classification des sciences*, 1898.

Hugo Muensterberg, *The Position of Psychology in the System of Knowledge*, Harvard Studies, vol. 1.

Karl Pearson, *The Grammar of Science*, 1900.

Herbert Spencer, *The Classification of the Sciences*, 1871.

Carl Stumpf, *Zur Einteilung der Wissenschaften*, 1906.

Wilhelm Wundt, *Über die Einteilung der Wissenschaften*, Philosophische Studien, 1889.

OUTLINE SCHEME OF THE CONTENT OF KNOWLEDGE PREPARED FOR MEETING PRESENT-DAY METHODOLOGICAL REQUIREMENTS.

SCIENTIFIC DETERMINATION OF THE GENERAL AND SPECIAL CONTENTS OF THE COSMOS.

§ 209.

Cosmology.

Non-protoplasmic and protoplasmic Matter, individual and pan-species Psychosis.
General, Universal and Non-Universal Cosmology.

General, etc., divided each, as practicable, into General, Universal and Non-Universal.
Physical, biological and cultural aspects of Cosmology. (1)

Presence of each cosmological aspect in all physical, biological and specio-psychic aspects. (2)
Correlation, co-ordination and unification of the departments of Physics, Biology and Specio-Psychics.

Physical—Biological—Specio-Psychic
(f) aspects in
Mechanics
Dynamics

Criticism of Science : Epistemology (3)
(7)

THE WORLD OF MATTER.		THE WORLD OF LIFE.		THE WORLD OF CULTURE.	
Physics.		Biology.		Specio-Psychics.	
Matter. Non-protoplasmic and non-sensitive. General, Universal and Non-Universal Physics. General, etc., divided each, as practicable, into General, Universal and Non-Universal. Biological and cultural aspects of Physics. (1) Presence of each physical aspect in all physical, biological and specio-psychic aspects. (2) Correlation, co-ordination and unification of the physical sciences, and of these with the biological and cultural sciences.		Life and individual sensibility. Protoplasmic and sensitive. General, Universal and Non-Universal Biology. General, etc., divided each, as practicable, into General, Universal and Non-Universal. Physical and cultural aspects of Biology. (1) Presence of each biological aspect in all biological, physical and specio-psychic aspects. (2) Correlation, co-ordination and unification of the biological sciences, and of these with the physical and cultural sciences.		Man as sole specio-psychic or cultural being. Culture as consisting of the pan-human store of inventions and discoveries. General, Universal and Non-Universal Specio-Psychics. General, etc., divided each, as practicable, into General, Universal and Non-Universal. Physical and biological aspects of Specio-Psychics. (1) Presence of each cultural aspect in all specio-psychic, physical and biological aspects. (2) Correlation, co-ordination and unification of the specio-psychic sciences, and of these with the physical and biological sciences.	
Mechanics, Gravitation... (4)		Botany (5)		Zoology (5)	
Virtually all plants consume only inorganic substances		Virtually all plants consume only inorganic substances		Virtually all animals consume only organic substances	
Flowering plants Monocotyledons, Dicotyledons Agriculture, Arboriculture, Horticulture ... Dietetic value of vegetable products Vegetarianism Vegetarian propaganda Pleasures of eating (7)		Flowerless plants Agariculture, Horticulure, Horticulture ... Dietetic value of vegetable products Vegetarianism Vegetarian propaganda Pleasures of eating (7)		Non-vertebrates Bees Apiculture Eating and enjoying honey	
Vertebrates Horse Riding School Out for constitutional (7)					
Ethnography, Religion... (6)				(2) Mechanical aspects in (Dynamical, ...), ... Astronomy, ...—Nutrition, ...—Painting, ... and aspects of these in Mechanics (Dynamics, ...), ...	
Love of Nature.		Love of Nature.		Love of Man.	

§ 210. To complete the classificatory scheme, we repeat from Conclusion 3 the Introductory Category and the Primary Categories.

I.—INTRODUCTORY CATEGORY.

The object of an enquiry is always a phenomenon, a phenomenon being a given or stated *partial* (e.g., portion of individual), *single* (e.g., individual as a whole), *collective* (e.g., aggregations of individuals to species), *grouped* (e.g., beyond species, and including larger wholes such as a science or a group or groups of sciences, to cosmology and the universe), or *abstracted* (whiteness, etc.), *physical or other something* (i.e., anything which partially or wholly exists, is coming into or going out of existence, has existed, will, might, could, would, should, or is believed, alleged or feigned, to exist, or the contrary).

II.—PRIMARY CATEGORIES.

1. Elementals	of phenomenon	} ungeneralised phenomenon.
2. Constituents	"	
3. Form	"	
4. Dependence	"	
5. Action	"	
6. Cause	"	
7. Resemblance	of phenomenon	} phenomenon classed.
8. Classification	"	
9. Position	"	
10. Differentiæ	of phenomenon	} phenomenon defined.
11. Details	"	
12. Value	of phenomenon	} worth of phenomenon.
13. Utilisation	"	
14. Appreciation	"	
15. Description	of phenomenon	} description of phenomenon.

This skeleton does not, however, offer its own explanation. We shall therefore develop each of the sub-sections.

A.—Material Aspects of Phenomenon Investigated:—

1.—ELEMENTALS, or Precise fundamental *sensory and other mental data* sought for in physical or mental investigations: (a) *vision*: light—colour—shade—transparency—picture—appearance; (b) *touch and effort*: softness—smoothness—evenness—cohesion—plasticity—flexibility—malleability, configuration—texture, gravity—weight—pressure—resistance, attraction—repulsion, fluid—liquid—viscid—solid; (c) *hearing*: sounds—noise—harmony; (d) *taste*; (e) *smell*; (f) *heat*; (g) *feeling*: pain—pleasure—appetite—desire—mood—excitement—emotion—sentiment; (h) *volition*: impulse—habit—decision—willing—action; (i) *intelligence*: observation—memory—imagination—reasoning—judgment—reflection; and (j) *indirectly ap-*

prehensible: causes of heat, electricity, magnetism, etc., and unconscious cerebration;

2. CONSTITUENTS, or Precise static and dynamic, largest to smallest, *constituents*, including ether, elements, compounds, minerals, vital constituents, materials, and parts, and their precise disposition, connection, interdependence, and relative homogeneity or heterogeneity;

3. FORM, or Precise *form*, shape, outline, design, of wholes, parts, sub-parts, etc., and their precise disposition, connection, interdependence, and relative homogeneity or heterogeneity;

4. DEPENDENCE, or Precise special facts and factors in the environment, on which the phenomenon is more or less *dependent* (e.g., tree's dependence on soil, atmosphere, and external temperature);

5. ACTION, or Precise *action* or effects of phenomenon;

6. CAUSE, or Precise *cause* or causes of the existence, and properties of phenomenon;

7. RESEMBLANCES, or Precise leading, major, and minor individual, class, and other *resemblances* of phenomenon or phenomena (for forming classes and schematic scale of classes);

8. CLASSIFICATION, or Precise methodical *classification* of the phenomena observed, and placing the classes thus formed under a more comprehensive category;

9. POSITION, or Precise *comparative position* of phenomenon within class or classes, and precise comparison of the parts of related wholes;

10. DIFFERENTIÆ, or Precise leading, major, and minor individual, class, and other *differentiæ* of phenomenon (the ascertainment of the leading *differentiæ* is the primary object of most investigations);

11. DETAILS, or Precise *secondary aspects* or details of phenomenon, of interest in the enquiry;

12. VALUE, or Precise *value* and *quality* (hygienic, economic, moral, æsthetic, philosophical, scientific, . . .) of phenomenon.

13. UTILISATION, or Precise *utilisation, application, and reproduction* of phenomenon in all spheres of life;

14. APPRECIATION, or Precise *appreciation* (desire, liking, preference, love, and enjoyment, and their opposites) of phenomenon; and

15. DESCRIPTION, or Precise *nomenclature, terminology, definitions, formulæ, statements, tables, diagrams, and reports* in connection with the phenomenon.

B.—Modal Aspects of Phenomenon Investigated:—

1. QUANTITY (precise number—magnitude—calculation . . .);

2. TIME (precise position and distribution in time, precedence—succession, number of times, dawn—day—twilight—night, seasons, past—present—future, duration—age—date, frequency—periodicity, rapidity—slowness, velocity—acceleration—retardation, chronological measurement and chronological calculation generally);

3. SPACE (precise position and distribution in space, before—behind—juxtaposition—direction, magnitude, number, height—depth—breadth, length—distance, angle, degree, longitude—latitude, compass points, metrical and other measurements, and calculation generally);

4. CONSCIOUSNESS (precise position and distribution in consciousness, precedence—succession, magnitude, number, vividness—completeness—durability, movement—changes, and resemblance in these respects of recalled phenomenon to phenomenon recalled, chronological, comparative, and other measurements, and calculation generally);

5. DEGREE (precise degree of Material, Modal, and Procedure Aspects of mathematical, etheorological, mechanical, physical, chemical, crystallographical, vital, sensory, psychological, social, specio-psychic, and other properties of a static or dynamic character, and of resemblance, difference, dependence, interdependence, and other relations and inter-relations, quantitatively stated where possible);

6. STATE (precise pure, average, casual, momentary, time-produced, environment-produced, individual, transitional, exceptional, abnormal, perfect, imperfect, and . . . state);

7. CHANGE (precise movement—activity—process, from commencement of change to its end, external and non-external influences, fertilisation—kariokinesis—prenatal development—birth—growth—adaptation—regeneration—reproduction—senescence—death—decomposition, evolution—origin—history—development—transformation or dissolution and further evolution, improvement—deterioration, production—accumulation—distribution—exchange—consumption, experiencing—feeling—reasoning—concluding, automatic-reflex—impulsive—habitual—deliberate action, and ways of living and their formation and change . . .); and

8. PERSONAL EQUATION (precise degree of more or less complete interest—preparedness—liberty—opportunity, of possessing stranger's freshness in viewing and weighing own facts and conclusions, and of more or less permanent individuality, abnormality, unclearness—ignorance—error—prejudice—deception, and . . .).

C.—*Procedure Aspects of Phenomenon Investigated:*—

1. Precise determination of the problem under investigation. (Conclusion 14.)

2. Accurate, minute, and, if possible, experimental examination under the most varied conditions of space, time, and other circumstances, and immediate and scrupulous recording of results. (Conclusions 16 and 18.)

3. Alertness, in order not to miss obscure, unobtrusive, and exceptional facts. (Conclusion 21.)

4. Systematic exhaustion, plus simple case and testing of divisions. (Conclusions 19, 20, 17.)

5. Degree-determination and dialectics. (Conclusions 27 and 28.)

6. Luminous clearness and decided definiteness in thinking. (Conclusion 15.)

7. Graded, comprehensive, important, numerous, full, rational and relevant, original, automatically initiated, and methodically developed generalisations, deductions, and applications. (Conclusions 25, 31, 32.)

8. Systematic verification, classification, balanced interim and final statements, and lucid reports. (Conclusions 29, 33, 30, 34, 35.)

FULLER LISTS.

§ 211. 3—7.

3. (a) *General Cosmology*, comprises the fundamental properties of the Cosmos;

(b) *Universal Cosmology*—Criticism and Theory of Knowledge, Theory of Being, General Methodology and Logics, . . .;

(c) *Non-Universal Cosmology*—Forms of matter and thought (space, time, . . .);

(d) General, Universal, and Non-Universal Cosmology, divided each, as far as practicable, into General, Universal, and Non-Universal.

4. (a) *General Physics*, comprising the fundamental properties of matter;

(b) *Universal Physics*—Gravitation; Etheorology—Light, Heat, Magnetism, Electricity, Radiation; Mechanics (molecular and molar); crystallography; chemistry; transition to life forms;

(c) *Non-Universal Physics*—(1) Astronomy (general, nebular, stellar, solar, planetary, terrestrial, . . .); (2) Geognomy—Gene-

ral; (2a) Sciences of the earth's interior (Metallurgy, Seismology, . . .); (2b) Sciences of the earth's solid surface and crust (Mineralogy, Geology, Geography, and sciences of mountains, valleys, shores, and waterbeds); and the general science of solid and viscous substances; (2c) Hydrology or Sciences of watersheds (*i.e.*, of seas, lakes, ponds, springs, runnels, brooks, rivers, underground reservoirs, clouds, saturated air, and of other water-affected and water-containing substances), and science of water and of liquids generally; (2d) Aerology—Meteorology and sciences of lower and higher air constituents and currents, clouds, air thermology and barology, relation of air to super-aerial and sub-terrestrial, to animate and inanimate, and to terrestrial phenomena generally, and (2e), general science of gases;

(d) General, Universal, and Non-Universal Physics, re-divided each, as far as practicable, into General, Universal, and Non-Universal.

5. (a) *General Biology*, comprising the fundamental properties of organisms;

(b) *Universal Biology*—Sciences of protoplasm, cell, tissue, organ, system of organs, organism, and their animate and inanimate environment; development of living forms generally, of particular species, of fertilised ovum to birth, of birth to death and decay, and further development of particular species; Sciences of sensibility, nutrition and excretion, adaptation and regeneration, growth, reproduction, senescence, and death; heredity, variation, and evolution;

(c) *Non-Universal Biology*—General: (1) Botany—General, Flowering and Flowerless Plants . . .; (2) Zoology—General; Invertebrates: Annulates, Molluscs, Radiates; Vertebrates: Mammalia, Birds, Reptiles, Amphibians, Fishes; Palæontology, Embryology, Anatomy, Histology, Physiology; Systems—Circulatory, Respiratory, Alimentary, Excretory, Reproductive, Skeletal, Epidermic, Muscular, Nervous, Sensory, Cerebral . . .;

(d) General, Universal, and Non-Universal Biology, each re-divided, as far as practicable, into General, Universal, and Non-Universal.

6. (a) *General Specio-Psychics*, comprising fundamental properties of pan-human or species-produced culture;

(b) *Universal Specio-Psychics*—Sciences of societies, groups, individuals, and their interrelations; Anthropology, Archaeology, Ethnography, Universal History, Socio-Geography, Demography . . .;

(c) *Non-Universal Specio-Psychics*—General: History (of individual, and of minor and major social, civic, provincial, sub-national, national, continental, and universal groups, institutions, and products); Philology, Phonetics, Etymology, Grammar, Gesture and Picture Languages, Telegraphic and other Signs and Signals, Paleography, Epigraphy; Economics (Wealth pro-

duction, accumulation, distribution, and consumption); Morals; Religion; Politics; Law; Arms; Medicine (Hygiene, Dietetics, Sanitation, Pathology, Insanity; Physician, Surgeon, Medical Specialist); Education (home, school, vocational, and self-education, training of teachers, principles and methods of education); Play; Arts (letters—alliterative, rhyming, and blank, metrical and non-metrical, verse; story, fiction, plays, appreciations, criticism, description, essay, history; rhetoric—reading, reciting, orating; melody—vocal and instrumental music; action—acrobatics, athletics, dancing, acting, deportment, refinement; realised imagery—drawing, decorating, painting [oil, fresco, water colour], etching, engraving, sculpturing, and artistic fashioning in all materials, architecture; arranging—dress, furniture, ornamentation generally, gardening, parks, town planning, and artistic crafts and crafts so far as artistic); Crafts (innumerable); Vocational Activities; Psychology; Aesthetics; Methodology (Classical and Symbolic Logic, General and Special Methodology), Metrology (Arithmetic, Algebra, Geometry, Higher Mathematics, Statistics, Graphics, Cartography, and, generally, measurement of quantity, time, space, consciousness, degree, etc.); Philanthropy, Internationalism; and Life;

(d) General, Universal, and Non-Universal Specio-Psychics, each re-divided, as far as practicable, into General, Universal, and Non-Universal.

7. The classification is to be systematically pursued, from the widest abstract truth to the most intimate experience of life or the smallest detail, and every sub-department, extensive or restricted, is to be subdivided, as far as practicable, into General, Universal, and Non-Universal.

§ 212. For methodological purposes of easy reference it would be invaluable if a handy volume were prepared, supplying in tables, charts, and by other means, a succinct survey of the whole field of present-day knowledge. Tables of varying degrees of fulness would be needed to suit the convenience of diverse classes of inquirers. At present methodological thinking is slow, cumbersome, uncertain, and comparatively ineffective, partly because of the difficulty of a comprehensive grasp of a given sphere of knowledge. Systematic accounts of a circumstantial character may be found in the best encyclopædias, and also in good text-books and primers of special departments, or groups of departments, of knowledge.¹ Naturally, each inquirer will, in addition, prepare special tables and digests to suit his particular needs.

¹ Darmstaedter's *Handbuch der Geschichte der Naturwissenschaften und der Technik*, may also be consulted with advantage.

SECTION XXIX.—FINAL STATEMENT.

CONCLUSION 34.

Need of Formulating a Final Statement.

§ 213. In an Interim Statement we embody the essence of what we learn through observation, experiment, generalisation, and verification. On the basis of this Conclusion, we proceed to deduction of a theoretical and practical order. Having accomplished this, we formulate the Final Statement which strives to subsume the whole of the knowledge provided by the enquiry, in order to avoid leaving the subject unsummarised and in confusion. Substantially this Statement will be only distinguishable from the Interim one by being richer on the theoretical side and by simultaneously incorporating the practical teaching of our enquiry; and as we have found it convenient to adumbrate the Final Statement in Section XXV, little remains beyond referring the reader to that Section. We shall, therefore, confine ourselves to supplying an example.

The story of mankind from earliest times to to-day, illustrating man's dependence on pan-human thought and endeavour, may be said to reveal the following laws of human life:—

A.—Past, Present, and Future:—

(a) The law of the limitless accumulation and variation of cultural or tool-made products, involving the subsidiary law of the development of error and of cultural and social inequality;

(b) The law of the limitless perfecting of cultural or tool-made products, involving the subsidiary law of the elimination of error and of cultural and social inequality;

(c) The law of the limitless growth of co-operation chronologically and geographically, involving the subsidiary law of the development and elimination of the spirit of exclusiveness;

(d) The law of the limitless perfectibility of the individual, involving the subsidiary law of the development and elimination of individual imperfections.

B.—Future:—

(a) The fact of the virtually completed accumulation and variation of cultural or tool-made products, involving the subsidiary fact of the virtual cessation of the development of error and of cultural and social inequality;

(b) The fact of the virtually completed perfecting of cultural or tool-made products, involving the subsidiary fact of the virtually completed elimination of error and of cultural and social inequality;

(c) The fact of the virtually completed growth of co-operation chronologically and geographically, involving the subsidiary fact of the virtually completed elimination of the spirit of exclusiveness;

(d) The fact of the virtually attained perfection of the individual, involving the subsidiary fact of the virtual cessation of the existence and development of individual imperfections.

C.—*Present*:—

(a) The resolve and striving to increase the accumulation and variation of cultural or tool-made products, and to discourage the development of error and of cultural and social inequality;

(b) The resolve and striving to perfect cultural or tool-made products, and to eliminate error and cultural and social inequality;

(c) The resolve and striving to increase the growth of co-operation chronologically and geographically, and to eliminate the spirit of exclusiveness;

(d) The resolve and striving to perfect the individual, and to eliminate individual imperfections.

D.—Finally, this dependence of man, and man alone, on pan-species thought and endeavour, may be said to be due to the fact that man, and man alone, has reached the stage in the general evolution of the intelligence (just beyond the higher apes) where the thoughts of others can be freely assimilated, this leading, in turn, to his native outfit coming to be adapted to cultural instead of to natural selection and living, and this, again, to men's dependence on pan-human thought and endeavour. On the practical side this involves the virtually complete dependence of the individual on mankind as a whole for the adequate satisfaction of his nature, and the shaping of the individual and group life on this presumption.

SECTION XXX.—REPORT STAGE.

CONCLUSION 35.

Need of Being Concise, of Carefully Summarising, and of Writing Acceptably.

§ 214. (A) *CONCISENESS*.—In the course of an enquiry, we should endeavour to crowd into a sentence or a few sentences each result obtained. It is advisable to proceed similarly when preparing the publication of the conclusions, for, in the latter circumstance also, the pithiest form of statement consistent with perspicuity is, for many reasons, expedient.

§ 215. (B) *SUMMARISING*.—Following Bacon, we should strive to compress the final result in a concisely worded formula or set of formulæ. Such a form of epitomising is in harmony with the process delineated in § 111, and is attempted in Conclusion 34. Concise summaries of each chapter, of each part of a volume, and a good table of contents and index, are desirable.

§ 216. *WRITING ACCEPTABLY*.—Much labour needs to be consecrated to the ultimate grouping which should present the conclusions in a brief, connected, luminous, and convincing form.

This arrangement, rigorously executed, will furnish the structure of the essay or book. Nothing short of such a mode of grouping is implied in the successful completion and publication of an enquiry. A volume brightly and brilliantly written, dotted with apt illustrations, prophetically inspired, sympathetic towards fellow-labourers, distinguished by a rich and illuminating vocabulary and a clear and flowing style free from diffuseness and acerbity, will materially enhance the probabilities of its conclusions being attentively and impartially considered. A slovenly or unconventional literary style retards in our age the recognition and the spread of truth. The investigator should, therefore, acquire the difficult and beautiful art of writing well. On the other hand, the perils inherent in this art are formidable. A causeur will convincingly chat through a bulky volume; one who possesses a capacious memory will present with effect countless superfluous and irrelevant illustrations; he who is insinuating, imaginative, or emotional, will captivate his audience; the ponderously dogmatical or methodical mind will be impressive; the sceptical or critical author will successfully deal out destruction—all with disastrous consequences normally on the progress of truth, where the intrinsic scientific requirements are partially or entirely ignored.

PART VI.

CONCLUSION CONCERNING CONCLUSIONS.

SECTION XXXI.—CONCLUSION CONCERNING CONCLUSIONS.

CONCLUSION 36.

Need of Respecting each of the preceding Conclusions in all the above Conclusions, of Improving them, and also of Applying them to Non-Scientific Matters.

§ 217. (A) *EACH CONCLUSION REFERS TO ALL CONCLUSIONS.*—At this stage of the enquiry it is unnecessary to intimate that each one of the foregoing Conclusions refers more or less to all of them, inasmuch as the whole treatment up to the present stage has evinced the oneness of the process involved in scientific enquiry. Deduction, generalisation, observation, a disciplined memory, imagination, verification, and definiteness should be resorted to, whether we determine anything regarding *this* object at *this* moment, or whether we examine some broad generalisation. Practically all the Conclusions and Sub-Conclusions referring respectively to Observation, Generalising, Definition, Deduction, etc., as indicated in Conclusion 2, need to be taken to apply with equal force to all of them and not only to the particular Section in which they are circum-

stantially treated. It was obviously inexpedient to crowd the Sections with repetitions, and only slightly more marked appropriateness decided under which heading a Conclusion should be scheduled, *e.g.*, the Conclusion dealing with verification.

§ 218. (B) *IMPROVING THE CONCLUSIONS*.—The series of Conclusions submitted herewith make no pretence to forming a self-contained and immutable system. Hence if they should commend themselves as a whole, the methodologists of the future will regard it as incumbent on them to improve the body of Conclusions in wording and in substance, to supplement them freely, to remove what is redundant, and to co-ordinate and fuse them to the furthest degree. The Conclusions are the outcome of over twenty-five years of conscientious examination and exploitation of the author's own experience and opportunities; and there exists hence every reason for believing that others who accept this volume as the point of departure for *their* life-long methodological researches, will be able to improve thereon substantially, apart from developing fresh sides—the practical and pedagogical sides, for instance—of the general problem of scientific methodology.

§ 219. (C) *APPLICATION TO PRACTICAL LIFE*.—In the economic life, in politics and city management, home and school education, art, play, the organisation of associations and conferences, in ordinary life and thought, in the world of feeling and willing, everywhere in short, the performing of actions on the most extensive scale and in agreement with scientific canons should be the invariable endeavour. The foregoing Conclusions apply, therefore, as repeatedly stated and especially in Conclusion 2, to the whole realm of human activity and not exclusively to what is styled pure science to-day, and their influence is likely to prove beneficial in the wider sphere as in the narrower. *Most especially should they be made the foundation of all education and of the urgently needed reform of the material and moral life of man.* In industrial enterprise this broad conception is fast gaining adherents, and, indeed, internationalism in every form stamps more and more the activities and purposes of this age, as was dramatically illustrated by the late War and by the ruinous economic crisis which followed it. The narrow individualist view of each man relying mainly on himself is being superseded, and it is presumably only a question of a few years when it will be acknowledged that a scientific methodology should guide men's cogitations and that the many valuable reflections and methods of individuals should be methodically collected, systematised, and disseminated broadcast.

§ 220. A generation ago the application of scientific methods to the problems of industrial and commercial efficiency appeared utopian. Routine, common sense, incidental improvements, ruled supreme, save in so far as machinery and organisation were concerned. The idea of analysing a task into its component

elements, and then reconstructing it along purely scientific lines, would have been dismissed as visionary. Employers would have contended that such an investigation may occupy months and even years; that it would interfere with production; and that it could not materially improve the practice of their generation. Yet to-day industrial methodology has reached in several directions almost the acme of scientific proficiency. The manner, for instance, in which motion studies, whose aim is the reduction of human movements in operations to the lowest practicable degree, are conducted, would probably not discredit the most punctilious of physicists or chemists. Frequently a year, or even two years, are spent on doing justice to a single process; machinery is created for the purpose; and the cost of such a study would ruin many a small firm.

Hitherto only the more elementary processes and the organisation aspects have been radically reconstructed (see Conclusion 10 for reasoned summary); but this is merely because one must begin with the lowest rungs of the ladder. Gradually the problems of accuracy, resourcefulness, improvement, invention and discovery, self-training, initiative, quickness of decision, *et hoc omne genus*, will be just as thoroughly dealt with—as movements of mind consisting of elements capable of being arranged according to an exacting ideal and yet readily acquired by the average individual—until an industrial methodology will be elaborated of a character far exceeding in thoroughness our present scientific methodologies. Competition a generation ago induced employers to turn away with scorn from the application of scientific methods to the problems of efficiency. Competition to-day is leading many employers to expend appreciable sums in order to increase the efficiency of their establishments by having recourse to the scientific reorganiser. Thus we are faced by the picture of the Cinderella, Industrialism, coming to the aid of the Princess, Science, and building up a system of methodology which is ultimately destined to enhance prodigiously the progress of the physical, biological, and specio-psychic sciences.

Commerce and Industry have therefore a great future before them. Efficiency means elimination of waste, a studious care not only of materials, but of human beings. Efficiency also means training and organisation. The feverish competition of the past, with the endless suffering which it entailed, the colossal waste it was responsible for, and the poor type of morality it encouraged, is hence bound to pass. Its place will be taken by a system of production, accumulation, distribution, consumption, finance, and insurance, based on scientific principles, and conducted by communities rather than by individuals. The stupid workman and the grasping capitalist will cease to be, and individual productivity and general well-being will be greatly enhanced. Every factory and office will be a laboratory,

and every worker and manager a miniature scientist. In a word, the present economic system is industriously digging its own grave and thoughtfully clearing the path for its successor. What science has done for the growth and organisation of knowledge, it is beginning to do for the growth and organisation of wealth. Stupendous progress in wealth production and well-being may be therefore confidently anticipated.

Eventually, no doubt, the two methodological streams will converge and travel down the ages as a single stream, each having benefited the other. Before this, however, is realised, other spheres of activity—education, public administration, law, hygiene, medicine, domestic life, religion, art—will be seized by the passion for scientific re-organisation, until science will dominate the whole universe of man's life and thought.

The advent of the scientific efficiency movement offers thus an auspicious omen for the triumph of the scientific method in practical affairs. It represents the most hopeful sign of the twentieth century, and probably spells the coming liberation of humanity from the serfdom of drudgery, poverty, ignorance, and barbarism.

To dwell for a moment on the relation between the efficiency movement and the methodology of discovery. Thorough in its way as the efficiency movement has been, the scientific foundations were neglected, because, first, practical men were at the head of the movement, men unskilled in the use of scientific instruments, and, secondly, because the scientific studies by means of dynamometer, ergograph, and the like, were not sufficiently advanced to be of practical benefit. Ultimately, however, basis and superstructure must become equally scientific, and the efficiency movement will be able to achieve its purpose completely.

On the other hand, the efficiency movement has a profound contribution to make to orthodox methodology. The latter's attention was concentrated on what we might denominate externals: truth and the mode whereby it may be reached. The fitness of the organism—psychological and physiological—received the scantiest attention. Yet the processes in discovery are subject to the same laws as the processes in industry, and if in the latter case far-reaching benefits accrue from an analysis and reconstitution of the processes, advantages no less desirable would ensue on a scientific analysis and basic reconstruction of the elements constituting the process of discovery on the subjective side. The prodigal waste of mental and physical movements would be removed, swiftness and labour- and time-saving methods would become universal, strenuousness would be general, exhausting fatigue would be reduced to a minimum, and everything tending towards rapidity and efficiency would be standardised and practised. More than this, the standardisation of efficiency processes will suggest the

standardisation of the processes of discovery, and the radical reconstruction of industrial processes will suggest the radical reconstruction of the general methodological process. Who knows whether the waste of mind in scientific research is not as great and detrimental at present as the waste of life under the existing economic régime? The two movements are, therefore, complementary, and destined to promote to a high degree each other's ends.

Perhaps a word should be said regarding the scope of the efficiency movement. It has been suggested that it constitutes a revolutionary advance analogous to that of the introduction of machinery in the closing years of the eighteenth century. It differs, however, from the latter in several respects. Machinery, as in the textile and printing industries, increases production sometimes more than a hundredfold, whilst, leaving aside the higher reaches, the former can scarcely be said to compare favourably in this respect: it may, speaking broadly, increase the general productivity of our day three times under favourable circumstances. On the other hand, whereas machinery is greatly restricted in scope, the efficiency movement applies to every activity whatsoever. What it therefore misses in intensity, it gains in extensity. The universality of its applicability therefore differentiates it from machinery. At the same time, in its higher reaches, it prodigally contributes to inventions and new machinery, and therefore indirectly rivals machinery in productivity. Moreover, and this represents another crucial differentiation, the efficiency movement demands perfect physical fitness and decided mental preparation and satisfaction in the worker, and thus abolishes for ever industrial exploitation and intellectual inertia and obtuseness. Machinery, plus efficiency, form hence the terminus of economic progress on the higher as well as on the lower planes.

As a remarkable instance, illustrating the application of science to industrial matters, we may regard the part played by index numbers in (a) authoritatively fixing for a whole country the relative increase or decrease in the cost of living, and (b) forming the universally accepted basis for raising or lowering wages in sympathy with the fluctuating cost of living. Already, however, statisticians are beginning to move a step further in order to decide on a minimum health-and-decency standard of living which shall form an objective guide for fixing "real" wages. Thus one of the most vital industrial problems, the solution of which in any particular case was normally secured at one time by the operation of casual prejudices and crude speculation, is coming to be solved by the application of a universal and purely scientific criterion. Nor is this all. The attainment of a certain standard of living is conditioned by a certain standard of individual productivity. Hence efforts are beginning to be made to arrive at an average unit or in-

dex number of individual productivity corresponding to a reasonable standard of life, and this will indubitably be followed by successful endeavours to establish the educational, training, workroom, and other conditions which shall yield this result. Hence the inevitable intervention of science in industrial affairs is bound to lead, among other things, to the realisation of a tolerably high standard of universal well-being and to a correspondingly high standard of average individual productivity.

§ 221. (D) *PERFECTING AND SATISFYING HUMAN NATURE AS A WHOLE*.—The chief subject-matter of the thirty-six Conclusions is the application of thought to the improvement of thought. Since, however, intellect constitutes only one aspect of psychic reality, the supplementary step should be encouraged to apply thought to the purification and ennobling of the personal, moral, and æsthetic feelings and to the strengthening and steadying of the will and character. In other words, the thirty-six Conclusions ought to be strenuously applied to the perfecting and satisfying of human nature as a whole. If our object in this treatise has been mainly to improve the intelligence, it is because knowledge is not only the one element which grows almost to infinity with the ages, but is, when truly apprehended, human nature groping for the means to satisfy and perfect itself.

§ 222. (E) *SUMMARY OF CONCLUSIONS*.—The thirty-six Conclusions may be thus epitomised for general purposes: *By habit and on principle intently, alertly, accurately, methodically, and rapidly observe, recollect, trace, generalise, deduce, verify, apply, classify, define, and improve static and dynamic facts separately and in combination, remaining always open-minded.*

(1) *By habit*—that is, always, unceasingly, spontaneously, as a result of thorough training.

(2) *On principle*—consciously, unswervingly, courageously, invariably.

(3) *Intently*—all the faculties continuously concentrated, strenuously employed, avoiding over-confidence and over-anxiety.

(4) *Alertly*—allowing no fact to escape; unerringly noticing exceptions and small items; all eyes and ears; keen; connecting new with old and old with new.

(5) *Accurately*—habit of unerring accuracy; not overlooking, exaggerating, understating, or mistaking anything.

(6) *Methodically*—developing every thought or suggestion methodically, nothing material being slurred over and everything material being embraced.

(7) *Rapidly*—with one means or instrument, with one single bodily or mental movement, exerting just the necessary energy, and with decided rapidity and pauselessness, to perform a great many desired actions; not to hesitate unduly.

(8) *Observe*—shunning hearsay, being observant, and observing or examining minutely, widely, and exhaustively as to space and time and circumstance; considering nothing as commonplace, settled, or uninteresting; persistently re-observing and re-examining for new facts; using instruments and experiment wherever practicable; keeping the faculty of wonder alive; being observant as to temporal, spatial, and ideational environment and causes.

(9) *Recollect*—observing with a view to remembering and recalling; guarding against a bad or unreliable memory by keeping adequate and accurate notes; training the memory and utilising it in constructive thought.

(10) *Trace*—explain, follow, interpret, completely account for.

(11) *Generalise*—to generalise, when practicable, every single static or dynamic fact to the entire class, and not only to a second or third fact; and at once, but step by step, to generalise from one class to a countless number of other classes related by degree and variety, until an imposing generalisation is, if possible, reached; to aim at circumstantial generalisations and not at mere empty and abstract propositions.

(12) *Deduce*—to deduce before being, and whilst, engaged in generalising, and afterwards; to base a deduction on reliable statements and test it adequately.

(13) *Verify*—to verify, re-examine, re-calculate a supposed fact; carefully to traverse ground passed over before; to examine in order to test a hypothesis, deduction, or statement.

(14) *Apply*—to apply a theoretical truth in its corresponding practical field, and convert a practical truth into a theoretical one; to let theory and practice minister to each other; to utilise every opportunity for as many purposes as possible.

(15) *Classify*—to classify results in an orderly manner, showing at a glance what has been attained, and connect the results with other and larger classifications.

(16) *Define*—to define the principal terms and the main conclusions compactly and as exactly as possible; to let one's reflections and statements tend to approximate rigid definiteness.

(17) *Improve*—always to think of how to improve upon what one has achieved or is engaged on.

(18) *Facts*—facts, imaginings, statements, events, happenings, processes, including the environment as a fact, factors, causes, forces, movements, conditions, relations, facts of space, time, and consciousness, and of number, degree, state, change, and personal equation.

(19) *Open-minded*—to regard all conclusions, results, and statements as more or less subject to correction; admitting the possibility of error everywhere; undogmatic, approachable, open to reason.

PART VII.

GENERAL CONCLUSION.

SECTION XXXII.—GENERAL CONCLUSION.

§ 223. Regarded as a connected body of precepts, the foregoing thirty-six Conclusions will probably be acknowledged as novel in the aggregate; but, historically speaking, they only seek to register the general advance of science. They attempt to perform for modern methodology what Bacon initiated, but, owing to a cruel fate and to the backwardness of the sciences of his time, did not consummate. They allow for the process of deduction and of mathematical treatment which Descartes championed. They recognise the historic and organic continuity of scientific discoveries. They encourage the conduct of enquiries as comprehensive and manifold as the development of the sciences at any period permits, enquiries occupying, if practicable, the space of a life-time. And, in respect of an ultimate aim, they, in a modern way, seek, as the precepts of Bacon and Descartes did, to improve human life in general.¹ Bacon, guided by a very small number of highly developed sciences, was at a distinct disadvantage in constructing his methodology. In this we are more favourably placed.² However, the author is far from assuming that the Conclusions formulated in this treatise uniformly reflect, as in a faithful mirror, scientific procedure at its best. He feels too deeply conscious of their incompleteness and imperfection, to claim

¹ "The true and lawful goal of the sciences is none other than this: that human life be endowed with new discoveries and powers." (Bacon, *Novum Organum*, bk. 1, 81.) "The project of a universal science which can raise our nature to its highest degree of perfection." (Mahaffy, *Descartes*, p. 65.) "There cannot be a greater mistake than that of looking superciliously upon practical applications of science. The life and soul of science is its practical application, and just as the great advances in mathematics have been made through the desire of discovering the solution of problems which were of a highly practical kind in mathematical science, so in physical science many of the greatest advances that have been made from the beginning of the world to the present time have been made in the earnest desire to turn the knowledge of the properties of matter to some purpose useful to mankind." (Lord Kelvin, *Constitution of Matter*, pp. 86-87.) Contrast these citations with the first sentence of Poincaré's *La valeur de la science*: "La recherche de la vérité doit être le but de notre activité; c'est la seule fin qui soit digne d'elle"; but possibly Poincaré included in his affirmation both theoretical and practical truths.

² "A technical science appears after the art with which it is concerned, has been for some time practised, and it reduces to rules that which has already been successfully carried out by proficients in the art." (Sigwart, *Logic*, vol. 2, p. 20.) Accordingly, the task of the twentieth century methodologist is manifestly far simpler than that of the seventeenth century methodologist.

for them what John Stuart Mill claimed for his Canons: "The mode of ascertaining those laws neither is nor can be any other than the fourfold method of experimental inquiry." (*Logic*, bk. 3, ch. 11, § 1.)

§ 224. There is nothing in the Conclusions submitted—methodised observation and computation, methodised recollection and reasoning, methodised generalising and deducing, methodised proving and defining, methodised application and methodised resort to these Conclusions in combination and in strict sequence, and a judicial and non-dogmatic attitude towards any important or unimportant conclusion reached—which requires any sixth sense, nothing which demands powers absent in ordinary mortals.¹ Who would seriously contend that the present practice in most of the cultural sciences to frame hypotheses without reference to a close study of the facts or to circumspect verification involves an inborn mental deficiency in those who proceed in this manner? Or why should it be alleged that generalising and deducing represent a process which could not be methodically and successfully pursued by all normal and trained individuals? Or that systematic work generally, or that objectivity, demands special aptitudes? If the marvellous machines and social organisations which mankind has evolved, stagger no sane individual, why should we conjecture that methodological modes of procedure, which are equally the outcome of ages of pan-human development, should be congenital in certain individuals and caviare to the average fully trained person? In fact, when one compares men's attitude towards nature and towards fables to-day and a few centuries ago, it is manifest that much of scientific thinking has already, where an educational system exists, penetrated into practically all layers of society, and this advance betokens that there is literally no limit to the general diffusion of methodological modes of thinking. Those who regard the operations involved in the process of discovery as a mystery, would in the past have probably imagined that natural and social events are originated by mysterious powers. In the one case as in the other we are face to face with a transitional mode of viewing the universe of things. Granted that everything valuable in humanity is the product of ages of co-operative reflection, then thought itself should be imagined as indefinitely improvable by the gradual discovery of the most efficient ways of conducting the human understanding. Superb by comparison with primitive times as is our present civilisation, it will become sublime and virtually divine when the twilight of variegated traditions is

¹ Our analyses of the processes involved in accuracy, resourcefulness, economy, improvement, and self-training, go far towards demonstrating that all proficiencies are composed of elements which any normal individual can assimilate.

scattered by the all-penetrating noon-day sun of a conscious and fully elaborated methodology.¹

Correct thinking is a pan-human product, whereas unscientific thinking merely argues thinking without the aid of a pan-humanly developed scientific method. Concede that a scientific method exists and is generally accepted and efficiently taught, and the millenium of the intellect should not be far off. Or, if this view should appear utopian, it will scarcely be denied that a relatively large minority would be able to profit substantially by the study of a body of Conclusions such as have been submitted in this treatise.²

§ 225. *Ultimately*, the object of this methodology is to supply a comparatively solid groundwork for the training of the masses of mankind, assisting the teacher to raise the average intelligence to a majestic level in comparison to the present one. An analysis of the scientifically trained and the scientifically untrained adult (Sections III and IV) justifies, we believe, such a conception. *Proximately*, the aim of this methodology is: (a) to supplement scientific tradition by a conscious general scientific method; (b) to introduce the scientific spirit into every line of enquiry and activity; (c) to encourage more particularly sound observation, sweeping though guarded generalisations, careful verification, exact definitions, and extensive theoretical and practical deductions, collectively applied in a certain sequence; and (d) to offer guidance to new sciences where, as in the cultural sciences, no effective methodological traditions as yet obtain.

¹ "There are no special peculiarities inherent in the scientific mind." (Prof. Arthur Schuster, in Presidential Address to the British Association in 1915.)

² "The course which I propose for the discovery of sciences is such as leaves but little to the acuteness and strength of wits, but places all wits and understandings nearly on a level." (Bacon, *Novum Organum*, bk. 1, 61.) To which Professor Fowler rejoins: "Bacon's promise never has been and never can be fulfilled." Of the two statements, Bacon's seems less extravagant, we submit.

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BIBLIOGRAPHY.

- Adamson, Robert*, Roger Bacon, Manchester, 1876.
- Agassiz, Louis*, Outlines of Comparative Physiology, London, 1851.
- Allen, Grant*, "The Progress of Science from 1836 to 1886", in *The Fortnightly Review*, June, 1887.
- The Hand of God and other Posthumous Essays, London, 1909.
- Ampère, André-Marie*, Essai sur la philosophie des sciences, Paris, 1834-43.
- Anderson, R.*, "Francis Bacon", in *Encyclopædia Britannica*, 9th edition.
- Apelt, Ernst F.*, Die Theorie der Induction, Leipzig, 1854.
- Aristotle*, Organon, and works generally.
- Arrhenius, S. A.*, Worlds in the Making, London, 1908.
- Ashley, M. A.*, "The Nature of Hypothesis", in John Dewey's *Studies in Logical Theory*, Chicago, 1903.
- Avebury, Lord*, On the Senses, Instincts, and Intelligence of Animals.
- The Scenery of England, London, 1904.
- The Scenery of Switzerland, London, 1913.
- Babbage, Charles, and Atherton, W. H.*, How to Invent Machinery, Manchester, 1899.
- Bacon, Francis*, De Interpretatione Naturæ Proœmium.
- Essay on Life and Death.
- Essay on the Winds.
- New Atlantis.
- Novum Organum.
- Of the Dignity and Advancement of Learning.
- Parasceve.
- Sylva Sylvarum.
- The Alphabet of Nature.
- Bacon, Roger*, The Cure of Old Age and Preservation of Youth, ed. 1683.
- The Mirror of Alchemy, ed. 1597.
- Bain, Alexander*, Logic, 2 vols., London, 1870-73.
- Banerjea, Indian Economics*, London, 1920.
- Barnard, Howard C.*, Outlines of Physical Geography, London, 1914.
- Bateson, William*, Mendel's Principles of Heredity, Cambridge, 1909.
- Beatty, James*, The Method of Enzyme Action, London, 1917.
- Beaumont and Fletcher*, First Folio, 1647.
- Bentham, Jeremy*, Chrestomathia, Part 2, London, 1817.
- Bergson, Henri*, Les données immédiates de la conscience, Paris, 1906.
- L'évolution créatrice, Paris, 1910.
- Bert, Paul*, First Year of Scientific Knowledge, Paris, 1885.
- Blanchard, A. A., and Wade, F. B.*, Foundations of Chemistry, London, 1914.
- Bloxam, Charles L.*, Chemistry, Inorganic and Organic, London, 1913.
- Boas, Franz*, "Instability of Human Types", in G. Spiller's (ed.) *Inter-Racial Problems*, London, 1911.
- The Mind of Primitive Man, London, 1911.
- Boole, George*, An Investigation of the Laws of Thought, London, 1854.
- Boole, Mary E.*, Logic Taught by Love, London, 1905.
- Bosanquet, Bernard*, Logic, 2 vols., Oxford, 1888.
- Bradley, F. H.*, The Principles of Logic, London, 1883.
- Brewster, Sir David*, Life of Sir Isaac Newton, London, 1875.
- Bridges, John H.*, Life and Work of Roger Bacon, London, 1914.
- British Association for the Advancement of Science, Reports of, for 1899, 1908, and 1911.

- Brochard, Victor*, De l'erreur, Paris, 1879.
- Brooks, William K.*, The Foundations of Zoology, New York, 1899.
- Browne, Robert*, "Hibernation", in Chambers' Encyclopædia, 1908.
- Browning, Robert*, Poems.
- Bruce, Henry* (editor), The Education of Karl Witte, New York, 1914.
- Brunschwig, Léon*, Les étapes de la philosophie mathématique, Paris, 1912.
- Carkins, Gary N.*, The Protozoa, New York, 1901.
- Caullet, Paul*, Eléments de sociologie, Paris, 1913.
- Chambers, Robert*, Vestiges of the Natural History of Creation, ed. London, 1887.
- Charles, Emile*, Roger Bacon, Paris, 1861.
- Clifford, W. K.*, Lectures and Essays, ed. London, 1918.
- Clodd, Edward*, Pioneers of Evolution, London, 1902.
- The Story of Creation, London, 1904.
- Coal Commission, Report of*, in Engineering and Industrial Management, London, March 27, 1919.
- Coffey, Peter*, The Science of Logic, 2 vols., London, 1912.
- Comte, Auguste*, Cours de philosophie positive, vol. 1, Paris.
- Positivist Tables, London, 1892.
- The Fundamental Principles of the Positivist Philosophy, London, 1905.
- Condillac, Etienne B.*, L'art de penser, Parme, 1775.
- L'art de raisonner, Parme, 1775.
- La logique, Paris, 1792.
- Cornelius, Carl S.*, Über die Bedeutung des Causalprinzips in der Naturwissenschaft, Halle, 1867.
- Cournot, M.*, De l'enchaînement des idées fondamentales dans les sciences et dans l'histoire, 2 vols., Paris, 1861.
- Couturat, Louis*, La logique de Leibnitz, Paris, 1901.
- Les principes des mathématiques, Paris, 1905.
- Cramer, Frank*, The Method of Darwin, Chicago, 1896.
- Creighton, James E.*, An Introductory Logic, London, 1905.
- Crowther, James A.*, Molecular Physics, London, 1919.
- Czapek, Frederick*, Chemical Phenomena in Life, New York, 1911.
- Darmstaedter, Ludwig*, Handbuch der Geschichte der Naturwissenschaften und der Technik, Berlin, 1908.
- Darwin, Charles*, The Descent of Man, London, 1885.
- The Origin of Species, London, final ed., 1917.
- Darwin, Sir Francis*, Charles Darwin, London, 1892.
- The Life and Letters of Charles Darwin, London, 1887.
- Dastets, J.*, Logic, Inductive and Deductive, 1905.
- Dauids, T. W. Rhys*, Buddhist Suttas (Translation), Oxford, 1900.
- De la méthode dans les sciences, Paris, 1910.
- De Morgan, Augustus*, Formal Logic: or, The Calculus of Inference, Necessary and Probable, London, 1847.
- Dendy, Arthur* (editor), Animal Life and Human Progress, 1919.
- Descartes, René*, Discours de la méthode, Paris, 1668.
- Desch, C. H.*, "The Simplicity of Natural Laws", in The Positivist Review, London, May, 1912.
- Desjardins, Paul*, La méthode des classiques françaises, Paris, 1904.
- Dewey, John*, How We Think, London, 1910.
- (editor), Studies in Logical Theory, Chicago, 1903.
- Dictionary of Philosophy and Psychology, Article Instinct, New York, 1911.
- Dryden, John*, An Essay of Dramatick Poesy, London, 1693.
- Duhamel, J.-M. C.*, Des méthodes dans les sciences de raisonnement, Paris, 1865-66-68, 1870-73.
- Durell, Fletcher*, Fundamental Sources of Efficiency, Philadelphia, 1914.
- Durkheim, Emile*, "Sociologie et sciences sociales", in De la méthode dans les sciences, Paris, 1910.
- Einstein, Albert*, Relativity, London, 1920.
- Ellwood, Charles A.*, Sociology in its Psychological Aspects, New York, 1912.
- Fishberg, Maurice*, The Jew, London, 1911.
- Flint, Robert*, Philosophy as Scientia Scientiarum, London, 1904.

- Foster, Sir Michael*, Presidential Address to the British Association, 1899.
- Fowler, Thomas*, Bacon's *Novum Organum*, Cambridge, 1878.
- *Logic, Deductive and Inductive*, Oxford, 2 vols., 1892-95.
- Freud, Siegmund*, *Die Traumdeutung*, Vienna, 1900.
- *Drei Abhandlungen zur Sexualtheorie*, Vienna.
- *Sammlung kleiner Schriften zur Neurosenlehre*, Vienna, 1911.
- *Studien über Hysterie*, Vienna, 1895.
- *Zur Psychopathologie des Alltagslebens*, Berlin, 1907.
- Geddes, Patrick*, "Biology", in *Chambers' Encyclopædia*, ed. 1908.
- *The Classification of Statistics*, Edinburgh, 1881.
- *Town Planning towards City Development*, 2 vols., Indore, 1918.
- "Variation and Selection", in *Encyclopædia Britannica*, 9th ed.
- Gibson, Boyce W. R.*, "Regulæ", in *Mind*.
- *The Problem of Logic*, London, 1908.
- Giddings, F. H.*, *Inductive Sociology*, London, 1901.
- *The Principles of Sociology*, London, New York, 1896.
- Gilbert, De Magneto*.
- Gilbreth, Frank B.*, *Motion Study*, London, 1911.
- and *Lillian M.*, *Fatigue Study*, New York, 1919.
- *Measurement of the Human Factor in Industry*, 1917.
- Giles, Herbert A.*, *The Civilisation of China*, London, 1911.
- Goblot, Edmond*, *Essai sur la classification des sciences*, Paris, 1898.
- Goldmark, Josephine C.*, *Fatigue and Efficiency*, New York, 1912.
- Goodrich, Edwin S.*, *The Evolution of Living Organisms*, London, 1912.
- Gratry, A.*, *Logique*, 2 vols., Paris, 1868.
- Gray, Andrew*, *Lord Kelvin*, London, 1908.
- Greene, Robert*, *Dramatic Works*.
- Gumplowitz, Ludwig*, *Grundriss der Sociologie*, 1905.
- Haddon, Alfred C.*, *History of Anthropology*, London, 1910.
- Harris, D. Fraser*, in *Science Progress*, April, 1916.
- Hartmann, Eduard v.*, *Philosophie des Unbewußten*, Leipzig, 3 vols.
- Hawkins, Edward L.*, *The Oxford Handbook of Logic, Deductive and Inductive*, London, 1913.
- Helmholtz, Hermann v.*, *Die Lehre von den Tonempfindungen*, Braunschweig, 1877.
- Herschel, Sir John*, *A Preliminary Discourse on the Study of Natural Philosophy*, London, ed. 1830.
- Hiorns, Arthur H.*, *Principles of Metallurgy*, London, 1914.
- Hobson, E. W.*, in *British Association Report for 1910*.
- Houssay, Frédéric*, *Nature et sciences naturelles*, 1903.
- Huxley, Thomas H.*, *Introductory*, London, 1900.
- *Man's Place in Nature*, London, ed. 1909.
- *Twelve Lectures and Essays*, London, ed. 1915.
- Iles, George*, *Inventors at Work*, New York, 1906.
- Jerusalem, Wilhelm*, *Die Urtheilsfunction*, Vienna, 1895.
- Jevons, William S.*, *Primer of Logic*, London, 1878.
- *The Principles of Science*, London, 1877.
- Johnson, Samuel*, *The Works of Shakespeare*, London, 1765.
- Jones, H. Gordon*, in *Positivist Review*, September, 1913.
- Jonson, Ben*, *Timber; or Discoveries made upon Men and Matter*, London, 1641.
- *Jonsonus Virbius; or, the Memory of Ben Jonson*, London, 1638.
- Jordan, D. S., and Kellogg, V. L.*, *The Scientific Aspects of Luther Burbank's Work*, San Francisco, 1909.
- Kant, Immanuel*, *Introduction to Logic*, London, 1895.
- *Kritik der reinen Vernunft*.
- Keith, Arthur*, *The Antiquity of Man*, London, 1920.
- Kelvin, Lord*, *The Constitution of Matter*, 1901.
- Keynes, John M.*, *Studies and Exercises in Formal Logic*, London, 1906.
- Kirkpatrick, Edwin A.*, *Fundamentals of Child Life*, New York, 1903.
- Klimpert, Richard*, *Lehrbuch der Akustik*, 4 vols., Leipzig, 1904-07.
- Lachelier, J.*, *Du Fondement de l'Induction*, Paris, 1896.

- La logique ou l'art de penser, Paris, 1662.
- Lamarck, Jean Baptiste, Philosophie zoologique, Paris, 1809.
- Lamb, Charles, Specimens of English Dramatic Poets contemporary with Shakespeare, London, 1808.
- Lankester, Sir Ray, The Kingdom of Man, London, 1912.
- "Zoology", in Encyclopædia Britannica, 11th ed.
- La Rochefoucauld, Duc de, Reflections, ed. London, 1904.
- Lee, Frederick S., The Human Machine and Industrial Efficiency, 1918.
- Lee, Sidney, Life of William Shakespeare, London, 1916.
- Legge, James, The Life and Teachings of Confucius, London, 1887.
- Leibnitz, G. W., See Louis Couturat.
- Lempfert, R. G. K., Weather Science, Edinburgh, 1912.
- Leverhulme, Lord, The Six Hour Day, London, 1919.
- Lévy-Bruhl, M., "Morale", in De la méthode dans les sciences, Paris, 1910.
- Lewis, W. C. McC., "The Structure of Matter", in Science Progress, January, 1918.
- Liebmann, Otto, Die Klimax der Theorien, Strassburg, 1884.
- Little, Andrew G. (editor), Part of the Opus Tertium of Roger Bacon, 1912.
- Locke, John, Essay on the Human Understanding, ed. London, 1829.
- On the Conduct of the Understanding in the Search for Truth, London, 1762.
- Locy, William A., Biology and its Makers, 1908.
- Loeb, Jacques, Forced Movements, Tropisms, and Animal Conduct, Philadelphia, 1918.
- The Dynamics of Living Matter, New York, 1906.
- Lotze, Rudolf H., Logic (Translation), Oxford, 1888.
- Lucretius, De Rerum Natura (Translation by H. A. J. Munro), London, 1903.
- Lyly, John, Dramatic Works.
- Lynch, Arthur, Psychology: A New System, 2 vols., London, 1912.
- Macaulay, Thomas R., Essays, ed. London, 1885.
- McBride, E. W., Zoology, Edinburgh, 1911.
- McCabe, Joseph, The Principles of Evolution, London, 1913.
- McDougall, William, Introduction to Social Psychology, London, 1909.
- Psychology, London, 1912.
- McKillop, M. and A. D., Efficiency Methods, London, 1917.
- Macdonald, J. S., Address before the British Association, 1911.
- Mach, Ernst, The Analysis of Sensations and the Relation of the Physical to the Psychical, London, 1915.
- The Science of Mechanics, London, 1902.
- Mahaffy, John P., Descartes, London, 1901.
- Malebranche, Nicolas, De la recherche de la vérité, ed. Bouiller, 2 vols., Paris.
- Marett, Robert R., Anthropology, London, 1912.
- Marlowe, Christopher, Dramatic Works.
- Marmery, J. Villin, Progress of science, 1895.
- Maxwell, J. Clerk, Theory of Heat, 1894.
- Medical Research Committee, Report on Accessory Food Factors, London, 1919.
- Meeker, Royal, "Minimum Quantity Budgets", etc., in Monthly Labor Review, Washington, June, 1920.
- Mellone, Sydney H., An Introductory Text Book of Logic, 1905.
- Mendelyeff, Dmitri I., The Principles of Chemistry (Translation), London, 1905.
- Meres, Francis, Palladis Thymia, London, 1598.
- Metchnikoff, Elias, The Prolongation of Life, New York, 1910.
- Milhaud, Gaston, Essai sur les conditions et les limites de la certitude logique, Paris, 1898.
- Mill, John Stuart, Autobiography, ed. London, 1909.
- A System of Logic, ed. London, 1884.
- Ministry of Munitions. Final Report of Health of Munition Workers Committee on Industrial Health and Efficiency, 1918.
- Minot, Charles S., The Problem of Age, Growth and Death, 1908.
- Minto, William, Logic, Inductive and Deductive, 1893.
- Mitchell, Peter C., "Parasitism", in Encyclopædia Britannica, 11th ed.

- Mitra, A. C.*, The Principles of Logic, Deductive and Inductive, 2 vols., 1912.
- Moore, Benjamin*, The Origin and Nature of Life, London, 1912.
- Morgan, Thomas H.*, Regeneration, New York, 1901.
- Morley, Viscount*, Notes on Politics and History, London, 1913.
- Muensterberg, Hugo*, The Position of Psychology in the System of Knowledge, Harvard Studies, vol. 1.
- Mukerji, A. C.*, A Text-Book of Inductive Logic, Allahabad, 1914.
- Myers, Charles S.*, Present-Day Applications of Psychology, London, 1918.
- Naden, Constance C. W.*, Induction and Deduction, London, 1890.
- Natorp, Paul*, Die logischen Grundlagen der exacten Wissenschaften, Leipzig, 1910.
- Naville, Ernest*, La logique de l'hypothèse, Paris, 1880.
- Newton, Sir Isaac*, Principia (Translation), London, 1729.
- Nunn, T. Percy*, The Aim and Achievements of the Scientific Method, London, 1907.
- Osborn, Henry F.*, From the Greeks to Darwin, New York, 1894.
- Papillault, G.*, "L'Hygiène Lamarckienne et l'Eugénique Darwinienne" in Le Progrès, Paris, 1913.
- Payot, Jules*, Le travail intellectuel et la volonté, Paris, 1920.
- Pearson, Karl*, The Grammar of Science, London, 1900.
- Phillips, Edward*, Theatrum Poetarum, London, 1675.
- Pitt-Rivers, A. Lane*, The Evolution of Culture, 1906.
- Plato*, The Republic.
- Poincaré, Jules H.*, La science et l'hypothèse, Paris, 1903.
- La valeur de la science, Paris, 1904.
- Science et méthode, Paris, 1908.
- Pope, Alexander*, The Works of Shakespeare, London, 1725.
- Poynting, J. H., and Thomson, J. J.*, Sound, London, 1913.
- Proceedings of the Society for Psychical Research, vol. 10.
- Ramsay, Sir William*, Essays, Biographical and Chemical, London, 1908.
- Rayleigh, Lord*, Scientific Papers, 4 vols., London.
- Theory of Sound, 1902.
- Read, Carveth*, Logic, Deductive and Inductive, London, 1906.
- Report of the British Association for the Advancement of Science, 1908.
- Report of the Indian Factory Labour Commission, 1908.
- Report of the Indian Industrial Commission, 1916-18, 1919.
- Ribot, Alexandre*, La logique des sentiments, Paris, 1905.
- Riehl, Alois*, "Logik und Erkenntnislehre", in Systematische Philosophie, by Dilthey and others, Berlin, 1907.
- Robertson, John M.*, Letters on Reasoning, London, 1905.
- Robertson, T. Brailsford*, "The Historical Continuity in Science", in The Scientific Monthly, October, 1916.
- Ross, Edward A.*, Foundations of Sociology, 1905.
- Roth-Scholtzen, Friedrich*, Deutsches Theatrum Chemicum, Part 3, Nürnberg, 1732.
- Rowe, Nicholas*, The Works of Mr. William Shakespeare, London, 1709.
- Royce, Josiah*, in Encyclopædia of Philosophy, vol. 1, 1913.
- Ruskin, John*, Frondes Agrestes, London, 1875.
- Russell, Bertrand, and Whitehead, N.*, Our Knowledge of the External World as a Field for Scientific Method in Philosophy, London, 1914.
- Principia Mathematica, Cambridge, 3 vols., 1910-13.
- Rymer, T.*, A Short View of Tragedy, with some Reflections on Shakespeare and other Practitioners of the Stage, London, 1693.
- Sandys, John E.*, Roger Bacon, London, 1914.
- Sargant, E. B.*, Report on Native Education in South Africa, Part III, 1908.
- Sarton, Georges*, In Isis, March, 1913.
- Schuster, Arthur*, Inaugural Address to the British Association in 1915.
- Scott, W. B.*, "The Palæontological Record—Animals", in Seward's Darwin and Modern Science, 1909.
- Seaman, Louis L.*, The Real Triumph of Japan, New York, 1908.
- Semon, Richard*, Die Mneme als erhaltendes Prinzip im Wechsel des Organischen Geschehens, Leipzig, 1911.

- Seward, A. C.* (editor), *Darwin and Modern Science*, 1909.
- Shakespeare, William*, *Dramatic Works*.
 ——— First Folio, 1623.
 ——— in *Cambridge History of English Literature*.
 ——— in *Dictionary of National Biography*.
 ——— in *Encyclopædia Britannica*, ed. 1911.
- Shearman, A. T.*, "Some Controverted Points in Symbolic Logic", in *Proceedings of the Aristotelian Society*, London, 1905.
- Sidgwick, Alfred*, *Fallacies*, London, 1883.
- Signart, Christoph*, *Logic* (Translation), 2 vols., London, 1895.
- Singer, Charles* (editor), *Studies in the History and Method of Science*, Oxford, 1917.
- Small, Albion W.*, *The Meaning of Social Science*, Chicago, 1910.
- Smith, D. E.*, in *Roger Bacon*, ed. by A. G. Little (whom see).
- Soddy, Frederick*, *Matter and Energy*, London, 1911.
- Spencer, Herbert*, *Essays*, ed. London, 1907.
 ——— *First Principles*, London, 1875.
 ——— *The Classification of the Sciences*, London, 1871.
- Spiller, G.*, "De la méthode dans les recherches des lois de l'éthique", in *Revue philosophique*, January, 1905.
 ——— *Outlines of a New World Religion*, London, 1919.
 ——— *The Distinctive Nature of Man*. (In preparation.)
 ——— *The Mind of Man*, London, 1902.
 ——— "The Problem of Race Prejudice", in *Inter-Racial Problems*, London, 1911, ed. by G. Spiller.
 ——— "The Problem of the Emotions", in *American Journal of Psychology*, vol. 15.
 ——— *The Training of the Child*, 2nd ed., London, 1919.
- Spinoza, Benedict*, *Tractatus Intellectus Emendatione*, ed. London, 1895.
- Stopes, Marie*, *Botany*, Edinburgh, 1912.
- Stumpf, Carl*, *Tonpsychologie*, vol. 2, Leipzig, 1890.
 ——— *Zur Einteilung der Wissenschaften*, Berlin, 1906.
- Subrahmanyam, A.*, *Logic, Inductive and Deductive*, 1911.
- Tannery, Jules*, "Mathématiques pures", in *De la méthode dans les sciences*, Paris, 1910.
- Taylor, Frederick W.*, *Shop Management*, New York, 1911.
 ——— *The Principles of Scientific Management*, New York, 1919.
- Taylor, Henry O.*, *The Mediæval Mind*, 2 vols., New York, 1919.
- Tennyson, Lord*, *Poems*.
- Thomson, J. Arthur*, "Heredity", in *Chambers' Encyclopædia*, ed. 1908.
 ——— *The Study of Animal Life*, London, 1917.
- Thomson, J. J., and Poynting, J. H.*, *Sound*, London, 1913.
- Thorndike, Lynn*, *Natural Science in the Middle Ages*, 1915.
 ——— *Roger Bacon and the Experimental Method in the Middle Ages*, 1914.
- Thorpe, Edward*, *History of Chemistry*, 2 vols., London, 1914-18.
- Times Literary Supplement*, July 29, 1915.
- Trivedi, A. K.*, *Studies in Inductive Logic*, 1914.
- Turner, H. H.*, "The Characteristics of the Observational Sciences", *British Association Meeting*, 1911.
- Tyler, Edward B.*, *Anthropology*, London, 1895.
- Tyndall, John*, *Faraday as a Discoverer*, London, 1868.
 ——— *Heat as a Mode of Motion*, London, 1887.
 ——— *Scientific Use of the Imagination and other Essays*, London, 1872.
 ——— *Sound*, London, 1893.
- Ueberweg, Friedrich*, *System der Logik*, Bonn, 1868.
- Venn, John*, *The Principles of Empirical or Inductive Logic*, London, 1907.
- Vogl, S.*, *Die Physik Roger Bacon's*, Erlangen, 1906.
- Vries, Hugo de*, *The Mutation Theory* (Translation), 2 vols., London, 1910-11.
- Ward, A. W.*, *A History of English Dramatic Literature to the date of Queen Anne*, 2 vols., 1899.
- Watt, Henry J.*, *The Psychology of Sound*, Cambridge, 1917.

- Watts, Isaac*, Logic, ed. London, 1811.
Waxweiler, Emile, Esquisse d'une sociologie, Brussels, 1906.
Webster, John, Dramatic Works.
Weismann, August, The Evolution Theory (Translation), 2 vols., London, 1904.
Welton, James, A Manual of Logic, 2 vols., London, 1896.
——— Groundwork of Logic, London, 1917.
Werner, Karl, Die Kosmologie und allgemeine Naturlehre des Roger Baco, Vienna, 1879.
Westaway, F. W., Scientific Method—its Philosophy and its Practice, London, 1912.
Whately, Richard, Elements of Logic, London, 1827.
Whetham, William C. D., The Recent Development of Physical Science, London, 1906.
Whewell, William, History of Scientific Ideas, 2 vols., Cambridge, 1858.
——— Novum Organum Renovatum, London, 1858.
——— On the Philosophy of Discovery, London, 1860.
Whitehead, A. N. (See also *Russell, B.*), Introduction to Mathematics, London, 1914.
Williams, Henry S., The Story of Nineteenth Century Science, New York, 1900.
Wilson, Edmund B., The Cell in Development and Inheritance, New York, 1902.
Windelband, Wilhelm, Prinzipien der Logik, 1912.
Wundt, Wilhelm, Logik, Stuttgart, 3 vols., 1906–8.
——— "Über die Einteilung der Wissenschaften", in Philosophische Studien, Leipzig, 1889.
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