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SYMBIOGENESIS.

**THE UNIVERSAL LAW OF
PROGRESSIVE EVOLUTION.**

SYMBIOGENESIS

THE UNIVERSAL LAW OF PROGRESSIVE EVOLUTION

BY

HERMANN REINHEIMER

AUTHOR OF

“NUTRITION AND EVOLUTION”

“SURVIVAL AND REPRODUCTION”

“EVOLUTION BY CO-OPERATION”

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Not as adventitious therefore will the wise man regard the faith which is in him.

It is not for nothing that he has in him these sympathies with some principles and repugnance to others. He, with all his capacities, and aspirations, and beliefs, is not an accident but a product of the time. While he is a descendant of the past he is a parent of the future; and his thoughts are as children born to him, which he may not carelessly let die.

—HERBERT SPENCER, *First Principles*.

Science, after all, should form a kingdom which is more or less not of this world. The ideal scientist should know neither self nor friend nor foe—he should be able to hob-nob with those whom he most vehemently attacks, and to fly at the scientific throat of those to whom he is personally most attached; he should be neither grateful for a favourable review nor displeased at a hostile one; his literary and scientific life should be something as far apart as possible from his social; it is thus, at least, alone that any one will be able to keep his eye single for facts, and their legitimate inferences.—SAMUEL BUTLER, *Luck or Cunning*.

The improver of natural knowledge absolutely refuses to acknowledge authority, as such. For him, scepticism is the highest of duties; blind faith the one unpardonable sin.

—T. H. HUXLEY, *Collected Essays*.

PREFACE.

The favourable reception accorded to my "Evolution by Co-operation: a Study in Bio-Economics," published in 1913, has encouraged me to come forward with a still greater effort towards the elucidation of the laws of natural co-operation and a more precise formulation of fundamentally important bio-economic principles.

The concurrent attempt to introduce the idea of "values" into Biology may be viewed as a sequel to my bio-economic studies. I think it may fairly be claimed that though it were but an attempt in this direction, it deserves to be welcomed as at least opening new avenues to biological and evolutionary thought.

Indeed, to judge by the reviews and correspondence that I have had, my work may be said to have entered that stage of general recognition where it is conceded that "there is something in it." As one well-known and distinguished writer puts it (who indeed declares himself to be captivated by its main idea though not yet entirely "captured" and considers the economic parallel illuminating in the highest degree): "That there is something in it is absolutely undeniable." I feel justified in expressing considerable confidence in a further growth of such favourable impression as the present work will assist in re-inforcing my position and as my views will become familiar to wider circles.

I have spent eighteen months of almost uninterrupted daily labour in compiling the present volume. Yet, were it not that I have been weighing the leading propositions now for a considerable number of years, I could not have completed a work of such dimensions in that short time.

I have once again great pleasure in acknowledging the help of my friend A. H. Singleton, to whom I here desire to express my cordial thanks for the unstinted assistance in the production of this work.

Surbiton, April, 1915.

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INTRODUCTION.

Il n'est pas vraisemblable que l'évolution sociale se trouve être exactement l'inverse de l'évolution organique. Plus probablement les lois générales induites de l'observation des êtres vivants sont ici à moitié vraies, applicables sur certains points, et portant à faux sur d'autres.

—C. BOUGLÉ.

When we know that living things are formed of the same elements as the inorganic world, that they act and react upon it, bound by a thousand ties of natural piety, is it probable, nay, is it possible, that they, and they alone, should have no order in their seeming disorder, no unity in their seeming multiplicity, should suffer no explanation by the discovery of some central and sublime law of mutual connection?

—T. H. HUXLEY.

Since the publication of my book on *Evolution by Co-operation*, further evidence in its favour has been rapidly accumulating on all sides, and all biological research, so far as I have been able to follow it in the last year or two, has brought to light strong confirmation on every hand of the main theses I have put forward.

I purpose now to consider a series of applications of my bio-economic theory with a view to showing that it complements the work of eminent biological writers past and present.

As a result of further study and of more insight gained, I here give greater emphasis to the factor of symbiosis than in my previous work and concurrently and, as the title of this volume indicates, am presenting a further elaboration of my theory in this direction.

The first chapter is particularly devoted to the subject of symbiosis, which is generally defined as a physiological partnership between individuals of different species, but which is of far more universal meaning and occurrence than is suggested by this definition. The term must be particularly applied also to the wider bio-economic form of co-operation which underlies evolution and unites all organisms in one vast web of life—in a veritable organic “civilisation.”

The various kinds of labour and of 'mutual services performed by organisms of all classes have their definite (quasi-economic) value in this organic civilisation. In the course of the development of this civilisation, *capital—physiological as well as "mercantile"—is constantly being created, and consists in both cases of accumulated values both of food reserves or surplus and auspicious or profitable capacities and trade relations. The incessant storing up of labour in the form of capital, and the continuous exchange of surpluses, are indeed as indispensable to the preservation and the progress of the organic world as to that of the body politic.* The true symbiosis here involved takes place not only in isolated cases of attached partnerships, but also on a grand scale in Nature. If it is generally less conspicuous than those few isolated cases of obvious partnership instanced by the text-books, it is all the more a genuine biological symbiosis—universal and far-reaching in its effects. If, as I hold, biological co-operation is indeed similar to economic co-operation, it follows that a distinction between biological (bio-economic) and physiological partnership is but artificial. Just as in human society domestic economy is part and parcel of national or international co-operation, so in the web of life all narrow or primitive forms of co-operation are but foreshadowings or variations of the wider biological forms of co-operation. Just as national law has its parallel in international law, and both act and react on each other, so in the world of life domestic laws are but parallels and reverberations of the wider laws of organic civilisation.

Nor does the term partnership even so exhaust the meaning of symbiosis, the effects of which are not limited to mere quantitative results, to mere stomach-happiness—*i.e.*, the production, distribution and consumption of the "good things of life"—although certainly it is a desirable consummation and also one of the material conditions of progress that "two blades may grow where there was but one before." The grand importance of symbiosis consists in the fact that it

evolves and safeguards those very modes of reciprocal differentiation which we must recognise as the universal means of the creation and elaboration of physiological and psychological values, including those which perhaps may be more especially regarded as genetic in character and influence. In other words, symbiosis is more than a mere casual and isolated biological phenomenon: it is in reality the most fundamental and universal order or law of life. So much so is this the case that I claim *the great principle underlying all Creative Life, all Progressive Evolution to be that of "Symbiogenesis"; i.e., the mutual production and symbiotic utilisation of biological values by the united and correlated efforts of organisms of all descriptions.* It is a well-known saying of Aristotle that the City exists for the sake of its good citizens, and I would apply it to the biological society, which also exists for its "good" citizens—those organisms, namely, which by symbiotic endeavour at once earn the right of biological citizenship and contribute to the welfare, permanence and progress of their "society."

The secret of progressive evolution, I contend, has always consisted in the operation of an important economic or *quasi*-economic principle such as that rendered emphatic by the results of organised human labour. As a French sociologist (Bouglé) expresses it: "Tous ceux qui ont analysé les effets de l'organisation du travail l'ont remarqué: la mise en commun des forces individuelles engendre une force totale plus grande que leur somme. Quelles qu'en soient les raisons diverses,—économies de temps et d'espace, entraînement et adaptation réciproque des efforts,—la combinaison des travaux augmente leur efficacité."

The accumulation and utilisation of biological capital, being racial (phylogenetic) rather than individual (ontogenetic) matters, it is important to trace the operation of these principles in the phenomena of heredity and genetics, which are to be regarded as a sort of racial nutrition, gestation in the

one case being parallel to digestion and maturation (of food) in the other.

It is said that "The eternal Feminine draws us on," and, indeed, how profound is the influence of sex! How much of values is there involved! Yet how little do we realise how the sacred flame of sex is constituted, how its potency is derived from the immemorial activities of manifold symbiotic forces. Far less still is it realised to what an extent a similar pair of symbiotic opposites (as male and female), and, indeed, a similar and fundamentally important symbiogenesis, are entailed in nutrition which as above said everywhere provides the parallel to sex.

Prof. Weismann's "amphimixis" (the mingling of parental qualities in fertilisation), which according to him is a great cause of progressive variation, is but one mode, viz., the domestic or the sexual mode of symbiogenesis. Nutrition is another, viz., the biological or bio-economic mode, no less important.

In previous volumes I have endeavoured to show, what is here becoming more apparent still, that nutrition is of such importance in genetics that we may fitly speak of nutritional "amphimixis" as preceding sexual amphimixis, and of nutritional "gestation" as preceding and complementing sexual gestation.

According to Goëthe, "Blut ist ein ganz besonderer Saft" (*i.e.*, blood is quite a special sap), and indications are emerging on every hand that similarly every food substance has its own particular significance according to origin, which seems to confirm my inference that the relations normally obtaining in feeding are definitely regulated by a fundamental biological requirement or law, viz., that of reciprocity, or, more widely stated, that of symbiogenesis. By symbiogenesis I mean the production and increase of values throughout organic life by means of a symbiotic principle of co-operation or reciprocity between different organs of the individual, but evolved and complex body, as well as between different organisms in a

species or different species, genera, orders, etc., even in the last and most fundamental way between plant and animal in the web of life. By the term symbiosis I refer to that obvious phenomenon of co-operation of parts and organisms as they occur, while by symbiogenesis I mean the principle underlying such symbiosis and indeed all instances of mutuality in the progressive transmutation of biological values generally. Symbiosis, further, may be *domestic* when it is between the organs of one organism and between the members of a family; *biological* when it refers to physically separate partners, even when widely separated and unconscious of partnership.

Coming back to the importance of nutrition and its parallelism with sex, it may be noted that Samuel Butler went so far in his biological visualisation as to say that eating is a mode of love, and that "Food is very thoughtful; through thought it comes, and back through thought it shall return," which is another way of emphasising the amphimixis aspect of nutrition. Eating, I should say, is a mode of love precisely in so far as it is an instrument of symbiogenesis.

Love is regarded as the greatest power on earth, and again this may be said to be so because Love may be primarily viewed as a symbiogenetic power. "L'amor che muove il sole e l'altre stelle."

"L'union fait la force" is another statement expressive of a similar idea. Biologically speaking, I should say: "La symbiose fait la force."

Even the bio-chemist's "biotic" energy, I am inclined to consider as but symbiotically compounded organic energy and organic experience. The fact that substances differ in their intra-atomic and general constitution as well as in their effectiveness, according to their origin, and that, further, "every form of protoplasm existent in any organism is stereochemically ordered in specific relationship to that organism, so that the products of synthesis have an impressed structure and manifest optical activity" (*Nature*, 9/7/14, p. 491), viewed in the light of symbiogenesis, suggests that every

species of organism has a definite bio-dynamic value according to which it affects the organic world for good or for evil, *i.e.*, in the direction of progress or of retrogression.

Prof. Reichert, of Pennsylvania, in his researches on hæmoglobin, has shown that this substance is modified in specific relationship to genus and species. He now extends the hypothesis to the study of starches, expecting to find that the peculiarities of the protoplasm in different species of plants will occasion the formation of different types of starch. "The variations in the starch granule with origin are, of course, well known, and they are of industrial importance." . . . "It may be considered as established that starches of different origin vary both visibly and in chemical properties." . . . "It would appear that over and above species variation, differences due to environment and nurture appear in the starches, and it is possible that the further study of such a substance as starch may provide material for the solution of many vexed problems" (*Nature*, 9/7/14).

Precisely, and what I maintain is that we are here concerned not merely with purely physical or chemical properties, but that it is primarily biological action and reaction (nurture and environment!) which determine, if not the entire composition, yet at any rate the mutual suitability or otherwise of substances for synthetic biological purposes.

I am providing in the present volume numerous illustrations in support of this view ("love-foods" as symbiogenetic substances, alkaloid and albuminoid poisons as pathogenetic substances), and I have also pointed out some striking forms of biological antagonism with which we are becoming increasingly familiar, and which go to show that all life is ruled by great bio-economic principles, the most prominent of which is, according to my view, symbiogenesis. Dr. John Beard has recently shown that the asexual generations of many animals are rapidly killed and digested by pancreatic ferments (Trypsin and Amylopsin), whereas frequently on the other hand the sexual generations are not in the least affected by

these enzymes. This points to a biological antagonism between sexual and asexual modes of reproduction, or, at any rate, it shows the inferiority of the latter because of its frequent more or less pathogenetic or symbiogenetically inferior origin, which easily renders it a source of danger to biological progress and calls for repressive measures in the protective adaptation of the progressive types. Dr. Beard suggests, indeed, that the difference of composition has to do with this biological antagonism between strenuous and pathogenic organisms, and that asexual forms are built up of dextro-proteins, whilst the sexual are built up of lævo-albumins. He contends that "the micro-organisms, bacilli, etc., of disease are of necessity composed of compounds which are, stereo-chemically, antitheses of those making up the normal human body—and that when they are compared with the pancreatic ferments, the like is true of the ferments by means of which they effect their ends. Only by means of such antithetic or opposite characters of compounds and of ferments produced by them could such disease-inducing organisms bring about their ravages. All of which is of considerable evolutionary significance and emphasizes the fact that Pathology is one of the most important chapters in Evolution. We must remember that its pronounced susceptibility to disease was one of Darwin's reasons for stigmatising perpetual self-fertilisation as "abhorred by Nature," which in reality provides a similar point of view.

It all shows that symbiogenesis involves a definite evolutionary path, and pathogenesis an opposite one, whence arises a determined and well-defined biological antagonism between the "good" (the symbiogenetic) and the "evil" (the predaceous, indolent and pathogenetic) types, which may result in wholesale destruction of the latter wherever a serious clash arises—indeed, wherever the respectively differentiated organic substances meet.

It thus becomes possible to determine the *value* of every substance, of every organic operation and development, and,

indeed, of every organism or species in the light of symbiogenesis, *i.e.*, of their symbiotic usefulness or the reverse in progressive evolution. Here, then, we have a means of determining what a French writer (Bouglé) terms “*les volontés de la nature*”—“*le critère objectif du bien et du mal.*” Here we have at last a valid measure of biological status and at the same time a sound basis for a rational system of evolutionary ethics—so sadly needed in these latter days of doubt and confusion.

In the first place, it is necessary to distinguish between those biological dynamics which go to establish physiological capital and those which have the contrary effect. In view of the fundamental importance of symbiosis—biological symbiosis largely determines the value of “domestic” symbiosis, as shown in Chapter I.—I have coined the terms *symbiotics* and *antibiotics*, the former to denote those specific ancestral activities calculated to enrich the organic world and, concurrently, the species itself, the latter to denote the opposite (anti-social) activities which may be seen in the long run to impoverish a species as they also tend to arouse various forms of biological antagonism and of nemesis.

The symbiogenetic view thus enables us to introduce into Biology a kind of applied dynamics, Bio-Dynamics, as I have termed it on the analogy with Bio-Chemistry, which latter is likewise, as I have endeavoured to show in this and previous volumes, receiving a new setting in the light of symbiogenesis.

Thus *equipped with a reliable standard of biological values*—un mètre du progrès—and with reliable bio-dynamic methods, we can undertake the study of genetics far more satisfactorily than has hitherto been possible.

It is the blending of matured reciprocal values that we are concerned with in genetics. This blending, of course, requires more than mere maturation of values. It requires a distinctly co-operative (symbiotic) disposition and preparation on the part of all those units more specially concerned in the blend. To be effective this

requires the possibility of a distinct symbiotic effort or "élan" by the parts entering into the alliance, *i.e.*, the evolution of sufficient rejuvenating and elevating power during the process of fertilisation, without which the latter is of not much avail and sterility ensues.

What is it that confers these powers, this "élan" in particular, upon organisms? I hold that it is their biological conduct which is primarily responsible for genuine genetic strength, for it is this conduct which, if symbiogenetic, purchases additional outside (biological) support in virtue of the valuable correspondences (biological correlations) which it sets up. I hold that *heritable biological correspondences constitute in great part the wealth of a species, and that therefore the mechanism of the inheritance of acquisitions must be looked for among these correspondences and their results quite as much as in the individual characters and powers of the organism itself, that is to say, that some of the factors making up such inheritance are in the (symbiotic) environment and cannot operate unless the symbiotic co-operation is fully carried out.*

My interpretation of genetic phenomena, in particular those bearing on Mendelian inheritance, may or may not commend itself to present workers in the field of genetics, but I venture to predict that it will appeal increasingly to those who are in search of causal factors and of qualitative analysis generally.

The same remark applies to the treatment I have given in subsequent chapters to Bionomics, Pathogenesis, Orthogenesis, and Psychogenesis respectively. In these chapters I wished, among other things, to show the need of Bio-Economics as applying to the whole field of Biology.

That the Nitrogen problem had to bulk large in these considerations is only in keeping with the general importance of this problem, so acutely and so widely felt in Biology, in Bio-Chemistry, as in Medicine, Genetics, and in Agriculture. My conclusion is that Nitrogen is a good servant but a bad

master, and that its use must be strictly in accordance with bio-economic requirements, *i.e.*, with symbiogenetic needs.

The abhorrence of Nature to indiscriminate and predaceous (non-reciprocal) modes of nitrogen-getting is clearly expressed, as I have shown, in the bad cumulative effects of perpetual "in-feeding" and in the more acute ill-effects, as evidenced by the clinical symptoms coming under the head of anaphylaxis or serum-disease (the modifications of the cells of an organism by the injection of "dissimilar" albuminoid substances so that they seem to react with greater intensity on the repetition of the injection). Perpetual in-feeding I believe to be on the road to Pathogenesis, which is the antithesis of Symbiogenesis. Most important bio-economic and evolutionary principles are here involved, and the more I pursue this study the more I am forced to conclude that we have as yet but touched the fringe of Evolution.

That some such principle as Orthogenesis, *i.e.*, progressive variation along a definite line, is widely operative in Nature, has of late increasingly suggested itself to our leading biologists, but I believe I am justified in saying that it has never before been as fully and convincingly demonstrated as by my symbiogenetic theory, how bio-economic factors provide a definite and persistent principle for the accumulation of variations. Symbiogenesis thus explains and complements Orthogenesis, or, at any rate, there is no progressive Orthogenesis (in a truly qualitative sense) without Symbiogenesis.

The importance of Symbiogenesis in the domains of mind and of Psychogenesis generally is very great, and throughout parallel to that which it bears to the creation of physiological and genetic values. If I have but scantily or fragmentarily dealt with this subject in Chapter VII., I hope that, at any rate, my treatment will prove of suggestive value in particular to physiological psychologists. There should be no antagonism between psychologists and physiologists or evolutionists.

The wholesome criticism applied by Samuel Butler to the

various evolution theories extant in his day, in particular to Darwin's natural selection theory, shows that we must strive at unification of knowledge, and again and again attempt to see things whole, *i.e.*, in the added light of new knowledge from all fields of experience, such, for instance, as Bio-Economics, which may also be defined as the combined study of the Physiology, Pathology and Biology of the self-preservation of organic civilisation, and of their indispensable interactions as a means to progressive development.

Although I own to a feeling of particular sympathy towards such admirable corrective attempts as those of Samuel Butler, supplemented as they were in his case by wonderful flashes of insight and by the heroism of genius, I have throughout wished to take up an impartial attitude towards all who have contributed their quota to the science of evolution, or any kindred science, on the principle that "Ehre dem Ehre gebühret" (Honour where honour is due).

The personal equation is ever dominating our views and determining our work, but we must sometimes, and at any rate in our judgment of our fellows, strive to rise above the influence of the personal equation, exclude all bias, and do justice to others as though personal interests were non-existent.

The personal equation has its place in the biology of daily life, but over and above it there are in this field also the claims of symbiogenesis which are those of an ulterior righteousness, or, as I have also termed it, a cosmic loyalty, serving the good, as it were, for its own sake and subordinating personal interests to the higher interests of humanity.

By recognising such claims we shall best fulfil the purposes of Science and further the progress of the world.

CHAPTER I.

SYMBIOSIS.

C'est rétrécir le sens du mot travail que de le limiter à la production industrielle.

Le travail se divise dans biens des cas où le commerce proprement dit n'est pas établi encore, et par d'autres influences que par la volonté réfléchie des individus.

L'agression brutale et sanglante n'est pas la règle universelle. La nature n'est pas animée tout entière d'un esprit de haine et d'envie. Le plus souvent, c'est sans se viser et même sans le vouloir, c'est sans animosité et même sans rivalité consciente que les êtres concourent et sont triés par la force des choses.

Il importe de rendre à la machine ce qui vient de la machine et à la loi ce qui vient de la loi.—C. BOUGLÉ.

The one thing needful for economic production is the green plant, as the sole producer of *vital capital* from natural *inorganic* bodies. Men might exist without labour (in the ordinary sense) and without land; without plants they must inevitably perish.—T. H. HUXLEY.

In *Evolution by Co-operation* I have put forward the theory of positive co-operation among organisms as a factor in evolution quite distinct from Darwin's Natural Selection by competition. I have there stated that co-operative principles have, in similar ways to those obtaining between bee and flower, prevailed throughout the whole course of evolution. From the moment division of labour set in, co-operation must have been essential to the organic world, for it afforded the best available means of preservation and progress. Just as in human society an invisible, but nevertheless actual and indispensable, standard of useful morality has gradually arisen, so also the biological world is ruled by an invisible but actual standard of domestic and bio-economic usefulness or social morality.

I have gone further, and—whilst emphasising the important part played by food—have pointed out that “It is the bio-economic task of organisms to earn their sustenance, and over and above this to provide for marginal and exchangeable bio-economic values to be used in the mutual accomplishment of evolution.” I have referred to Sir E. Ray Lankester’s recent statement that “the system of elaborate service of one organism to another is now found on examination to be practically universal,” and I believe that I have to a certain extent shown that “nothing, in fact, at the present day wants emphasising more than that the whole organic world is primarily and normally based on relations of mutuality, and that every step that transgresses these relations leads towards degeneration and decline.”

I have expressed the opinion that the fact that Darwin borrowed no ideas from political economy beyond the Malthusian doctrine constitutes a great defect in the Darwinian outlook, and I have shown that other and more important teachings of political economy apply as fully and fitly to the economic relations governing the world of biology. I have quoted the botanist Kerner’s view that such symbiosis, as is implied, for instance, by the relations between bee and honey-flower, shows a reciprocity which is at bottom but a copy of the complementary interaction of plant and animal which takes place on a grand scale in the organic world, and I have set this view in juxtaposition to Darwin’s pronouncement that “we are profoundly ignorant of the mutual relations of the inhabitants of the world,” and have shown that the neglect of symbiosis has led to many serious misapprehensions of the general philosophy of biology. For the benefit of those of my readers who have not read my *Evolution by Co-operation*, I cannot do better than here append part of a review of this book appearing in the *British Medical Journal* (25/4/14).

The title of his book, *Evolution by Co-operation*, affords a clue to his main position, which is akin to that of Drummond, Chambers, and, to some extent, Lamarck. He is of opinion that nutrition is a dominant

factor in the evolutionary process, and that, whereas adequate feeding is indispensable to orthogenesis, a *super-adequacy* of force, derived from a nutritional basis, is needed to achieve rise of type. He finds everywhere throughout organic nature evidence of a symbiotic reciprocity, so that healthy organisms and thriving species may be compared to trading individuals and communities, whose claim to survival rests on the production of commodities or the rendering of services indispensable to others. He believes that there is a law relating to nutrition analogous to that stated by Darwin with regard to fertilization, which, in corresponding terms, runs thus: "Nature abhors perpetual in-feeding." By the term "in-feeding" he denominates the indolent appropriation of food manufactured by close relatives, and the correlated shirking of the economic duty of production, or of mutual service in some kind. By the term "cross-feeding," on the other hand, he designates what he conceives to be the norm of healthy nutrition, since he finds in the properly matured products of plant life food material ideally adapted to the requirements of the animal world. His main objection to Darwinism is that it makes the mere fact of survival the criterion of biological success and value, whereby the liver-fluke becomes the peer of the philosopher. But, in the author's view, parasitism is the last stage of a pathological process, of which insectivorism is an early and carnivorism the intermediate manifestation.

In the present chapter it will be my endeavour to deal more fully with the far-reaching importance of symbiosis, and to show that the new knowledge to be gleaned from its study—especially if it is duly complemented by my own and other new conceptions now gaining ground in the various provinces of science—is precisely calculated to fill that hiatus in Darwin's theory, which—on his own admission (as stated above)—was bound to remain so long as such knowledge was lacking.

In a useful and fascinating little work on *Plant-Animals: A Study in Symbiosis*, Prof. F. Keeble shows how the study of the lower forms of life is of importance towards a fuller understanding of the more complex higher forms. The eminent botanist states that the higher the organism, the more it has covered up the tracks along which the species to which it belongs has travelled, and that for this reason alone the study of the lower organisms is not only to be justified but also urged on zoologists, as one bound to lead to results of the greatest value. But though this be so, our business in

following mainly the outlines of Prof. Keeble's study will be to elucidate the Bio-Economics of Symbiosis—primitive and complex, domestic and biological—so far as they can be gleaned or inferred from his results and as they must be supplied from other considerations.

If we hold with Darwin, that all animals and plants are descended from some one prototype, a belief strongly emphasised by modern embryology, we can see that all particular knowledge concerning primitive plant-animals may well be calculated to throw fresh light on the perennial and transcendently important problem of complex symbiosis constituted on a grand scale in nature by the inter-relations between plants and animals. "It is genius"—according to Prof. J. Arthur Thomson—"to give a thrill of fresh interest" to that topic of inter-relations. Though we shall have to differ from Prof. Keeble's exposition of plant-animalism, as far as economic interpretations are concerned, we shall, at any rate, be assisted by it to catch a glimpse of those primordial relations which, I submit, we must assume to have subsisted in the common ancestor of plants and animals, and which must necessarily have gone far indelibly to impress a symbiotic stamp or momentum upon all subsequent organisation.

Prof. Keeble takes two simple marine worms, *Convoluta roscoffensis* and *Convoluta paradoxa*, lowly, unsegmented organisms with a primitive digestive tract, but yet possessed of a well-defined nervous system and efficient sense-organs, although without any proper circulation or excretory apparatus. Soon after they are hatched these small creatures, which live on the edge of the sea in Brittany (and represent Prof. Keeble's *Plant Animals*), swallow with their food certain algal cells. For a time they continue to feed and grow, and as they do so the swallowed cells divide and multiply, until eventually the masses of these cells occupy a great part of the animal's body and turn it green. The colouring matter is chlorophyll, a substance which, in the leaves of plants, has the power of converting certain inorganic materials into starch,

and manufacturing food. It has the same power here, and the food thus provided suffices for the animal as well as for the plant within it. Hence we are confronted by the interesting problem of plant-animalism (symbiosis).

Among the general characteristics pointing to what I call "ancestral dynamics" of the kind we are here concerned with, the "periodicity" of the life processes in *Convoluta* is an item which offers food for reflection. It may be, suggests Prof. Keeble, that such adaptations as we are here concerned with are "as much a property of protoplasm as weight is a property of matter, and that the biologist is performing a service in showing how deep bitten into the organism are the adaptations whereby it adjusts itself to its environment." Precisely. When we come to organisms, having regard to the fact that they are composed of matter, we find that they are subject to very much the same circumstances as matter, but super-added to the bond of gravity, in their case, is the bond of organic solidarity, constituted by common descent and by the inter-relatedness of the world of life. Within these limits they form their respective adaptations, their respective characters. That these are frequently "deep bitten" into organisms results from the obvious primordial need of reliable character and reliable degrees of inter-relatedness, as we shall see more fully later, and this need is primarily a bio-economic need.

At the lowest stages of life, character is little developed; but, surely, we need not therefore infer that organic adaptation is an altogether mechanical business, that the physical environment has the identical coercive force upon an organism that it has upon inorganic matter. This is an instance where too exclusive a study of primitive life—showing little development of autonomous powers—might easily become misleading.

C. Bouglé, of the Sorbonne, in his useful summary of the various sociological and related biological schools of thought, under the title of "*La Démocratie devant la Science*," very correctly reminds us that biological study by itself is very apt to mistake phenomena essentially economic, *i.e.*, voluntary

and "historic" for "natural," i.e., mechanical, or involuntary or "non-artificial" phenomena.

En même temps rejetant les origines du phénomène de la division du travail dans un passé infiniment lointain, il [le progrès biologique] nous déshabitueait de le regarder comme une œuvre en quelque sorte artificielle, issue d'un contrat débattu entre échangistes. Rattacher, comme à son principe unique et universel, la division du travail à l'échange commercial, c'était prendre un accident pour l'essence, une "catégorie historique" pour la forme naturelle et nécessaire.

Prof. Keeble does not bind himself to either a mechanical or a teleological view. He will not rest content with a teleological explanation.

To say that this animal does such and such a thing because it is convenient or useful for it to do that thing is to renounce profound investigation. Before this can be regarded as the proper philosophical attitude towards life, the resources of chemistry and physics must be exhausted, and the behaviour under consideration must at least be proved *not* to be due to a chemical or physical change induced by some factor or factors of the environment.

In other words, the least the physiologist can do is to attempt to discover how the adaptive trick is performed by the animal which exhibits it.

The truly philosophical view can only gain if such full physiological and chemical investigation of the phenomena of adaptation be supplied. I here, also, find myself in complete agreement with Prof. Bergson, who holds that philosophy must take account of all the sciences have to offer, that theory of knowledge and theory of life are inseparable, and should push each other on unceasingly.

As regards the particular form of adaptation showing itself in the periodicity of reproductive processes in *Convoluta*, we are told that it is "for one reason or another" ultimately connected with nutrition. This is of special importance for my contention. With nutrition the ground is shifted from mere Chemistry and mere Physiology to a subject that, though it must include both, yet is greater than either, viz., Bio-Economics. As soon as we study nutrition in its wider aspects—production, distribution, and the concomitant biological inter-

relations—it becomes apparent that the ultimate facts of Physiology are also ultimate bio-economic facts. This—if, indeed, a comprehensive philosophical view is to prevail in Biology—it is vitally important to remember.

Nutrition entails work and division of labour. "Work," in the proper sense of the word, is therefore the real ultimate fact underlying all "adaptation," as it also, in my opinion, underlies all form. The first and most abiding requirement of the organic world is adequate nutrition, and this has necessitated the constant performance of work and continuous symbiotic endeavour from the very first. To produce or not to produce, that is the question at every stage of life, even the most incipient.

Let us see whether this thesis is supported by the results of modern science. First as regards the evidence from Prof. Keeble's work:—

It may be premised that if adult *C. roscoffensis* are kept in darkness for some time previous to the full development of their eggs, no egg-capsules are laid. The lack of egg-production on the part of dark-kept animals is due to the fact that animals kept under such conditions become starved and, as a consequence, incapable of supplying the eggs with food-materials.

The starvation in this instance is due to the fact that in the absence of light, the plant partner of *Convoluta* is unable to do its share of work, and, hence, to co-operate and to provide its usual contribution of food material. The mutual dependence in this instance of symbiosis has become too great to allow the partners to resume independent existence. If *Convoluta roscoffensis* is robbed altogether of its ("infecting") green cells, "life is not worth living, and it dies though surrounded by a plentiful micro-flora of which in happier, infected circumstances it avails itself without stint."

What is it, then, which determines the success or otherwise of the Convolutal adaptation, and which forms "der feste Punkt in der Erscheinungen Flucht" of all adaptation? It is work. Organic life cannot for long afford to be deprived of the possibility of work.

This is more particularly apparent so far as photosynthesis is concerned, the special manufacturing process of the plant—the most wonderful example in the world of life of systematic and vital work unceasingly and ungrudgingly performed. Experimental Morphology has shown that a reduction of the general production of organic substances (especially of carbohydrates) by a plant can be brought about in many cases by a diminution of the intensity of light, which interferes with its photosynthetic process of manufacture. In view of the fact that the general productiveness of a plant determines its status in the biological scale, we see how emphatically the evolutionary position and fate of a plant must depend on work. In the case of a plant an artificial diminution of its usual output of biologically valuable substances is generally attended by an undue predominance of vegetative growth at the expense of sexual development: all of which makes for retrogression as we shall see more fully later on. The assimilation of carbon by a plant is, of course, part of its photosynthetic process of manufacture, and Prof. G. Klebs* states that it is essential to the sexual reproduction of algæ, for instance, that a “vigorous production” of the materials formed during carbon-assimilation should take place. All his evidence from the point of view of Economics and still more of Bio-Economics must be interpreted to mean that work (productiveness) is the one great essential to progressive life. That, inversely, cessation of work for any length of time, universally (in the case of all organisms) leads to degeneration is, of course, a well-known phenomenon.

According to this evidence, then, I am scarcely making too much of this point of “work” in representing it as of at least equal importance in organic evolution as it is, according to the “gospel of work,” in human civilisation.

But, it may be asked, does not this theory of Bio-Economics perhaps make too exorbitant a demand on the willingness

* See his contribution to *Darwin and Modern Science*.

of physiologists to grant a certain degree of incipient personality, character, and intelligence to all organisms, however humble? Some, no doubt, there are who will say that it does. Let us see what we may infer from Prof. Keeble's conclusions. He tells us that:—

The fact which stands out most prominently from open-air observations of *C. roscoffensis* and *C. paradoxa* is that the behaviour of these animals is complex and purposeful. By some means or other they create for themselves an ordered life, in spite of the welter of change in their environment. Through the ever-varying conditions of the world in which they live, they thread their consistent way as surely as we, with conscious self-control and agility, pick our ways safely through the crowded traffic of the street.

This view, then, concedes the incipient circumspection of primitive life required by my bio-economic theory. When Prof. Keeble says that organisms achieve these high ends "by some means or other," I would interpret it to mean: by "work." The beginnings of psychological activities and of "work" (systematic, *i.e.*, useful activity), and, indeed, the beginnings of (organic) civilisation, must, as we shall presently see more fully, be dated back much further than has hitherto been supposed. This is one of the lessons which the consideration of the life of the plant-animals will have to teach us, although we need not confine ourselves to this subject alone for evidence. Thus Prof. Klebs, who is a leading botanical experimentalist, speaks of "the inner world" of organisms, the importance of which, as he says, increases with the degree of differentiation.

Again, when Prof. Keeble concludes that the connection between perception of impulses by a plant and the subsequent excitation of the living substance of its tissues differs only in degree but not in kind from the nervous phenomena of the higher organisms, and that the mode of orientation is determined by the plant itself, and has in each case a purposeful significance, we have again an appreciable approach of similarities between lowest and highest forms of life. The

same may be said of Prof. Keeble's consideration of protoplasm :—

The "nervous impulse" may well be of chemical nature, and transmission of such an impulse through living tissues does not connote definite specialised nerves. It is as much the property of protoplasm to transmit nervous impulses as it is of fire to burn, or of a lit fuse to explode a charge of gunpowder. Protoplasm is an apparatus for that purpose; as well, of course, as for other purposes.

The universal (protoplasmic) kinship of life is thus brought home to us, and the inherent proclivity of that mysterious element "life" for certain activities—in particular those calculated to uphold and to advance it—is manifested. We see that the natural proclivity of organisms for work has a universal significance, *i.e.*, as indicating the persistence of that kinship of life. We realise that living protoplasm is an apparatus for "work." It is equipped for "work." So much so, that all evolution is based on this equipment for "work." This is our economic interpretation of Prof. Keeble's remark that "Evolution, as we know it, has but resulted in the perfecting and complicating of these reflex arcs," which are adaptations for increasing efficiency for work.

How much depends in evolution on the development of those autonomous powers postulated by my economic theory becomes evident after a brief consideration of the tropistic behaviour of the plant-animals in the laboratory as given by Prof. Keeble. He concludes that reflexes are no more the masters of an organism than are conscious acts. They are but servants assisting the organism to accomplish its ends.

Under abnormal and well-nigh impossible conditions, the organism, high or low, is an automaton—the creature of inevitable nervous responses—reflex or conscious. Under normal conditions of life it responds now this way and now that to external or internal stimuli, and so appears to act as a free agent. . . The apparent inevitability of reflexes is but an indication of habit. . . Hence, by playing on its habitual tropisms, it is easy in the laboratory to lure an organism to its doom.

The universal equipment of living protoplasm for work

and the presence even in incipient life of autonomous powers, regulating work, thus corroborates the bio-economic view that organisms are primarily and normally free economic agents. They are not only to a certain extent masters of their own fate, but they are also to a certain extent responsible members of the biological community. Though they are frequently found to be slaves to habit, it by no means inevitably or even normally follows that this should ever be to an excessive extent. It is only where we find organisms lapsed into abnormal feeding (and associated abnormal economic) habits that they become "extremely determined" by the environment, *i.e.*, aberrant or degenerate, and in course of time unable to retrace their steps and therefore obliged to drift into blind-alleys of evolution. An extreme instance of such aberration is provided, according to my view, by parasitism inseparably associated as it is with metabolic abnormality. The "abnormal and well-nigh impossible conditions" referred to by Prof. Keeble under which the "organism, high or low, is an automaton," in my opinion, are realised by obligate parasites with their extremes of metabolic aberration and the concomitant extreme degrees of biological nemesis.

The same explanation applies, I believe, to the case of the extinction of races in nature which so greatly puzzled Darwin, for in nature, as in the laboratory, as, indeed, in human society also, organisms are being lured to their doom by becoming slaves to bad habits.

By a series of experiments concerning the behaviour of the plant-animals with reference to black and white backgrounds, Prof. Keeble believes that he has demonstrated that there is no inevitableness of reflex. Circumstances alter reflexes. There are, of course, limitations to all nervous actions, both reflex and conscious. The further inference is reached that:—

The behaviour of both plant and animal would seem to indicate that, in the reflex groundwork of nervous activity, something akin to the phenomenon of attention in psychic life may manifest itself.

This is another adumbration of incipient psychology as involved by my bio-economic theory. The subject of mind in evolution will be more fully dealt with later.

Evidence seems, according to Prof. Keeble, to be accumulating that frequently tropistic response is ultimately connected with nutrition, and that hence, as I submit, feeding habits largely determine whether an organism is to have a "place in the sun" or not. Prof. Keeble here bases himself on Prof. Jacques Loeb's experiments with fresh-water Copepods (small Crustacea). This is what they seem to indicate together with Prof. Keeble's comment.

Copepods feed, no doubt, on algæ, which can only live and grow in the light. In the course of their nutrition, algæ decompose carbon-dioxide and liberate oxygen, so that the amount of carbon-dioxide contained in the water in their immediate neighbourhood is less than that contained in the darker regions of the pond. Much carbon-dioxide will be correlated with limited food supply. Now it has been shown definitely in the case of other animals, *e.g.*, the caterpillars of *Porthesia*, that they are only positively phototropic so long as they are not fed. If this holds good for Copepods, their response to increased carbon-dioxide becomes at once intelligible on the mnemo or associated stimulus hypothesis. Thus hunger affects the tone or physiological state in such a way that the Copepods respond to light by directive movements whereby food supplies become available. The movement brings the animals from a part of the water which contains a maximal amount of carbon-dioxide to a part where, thanks to the presence and activity of the green algæ—the food sought by the Copepods—the water is not fully saturated with carbon-dioxide. When the animal encounters carbon-dioxide conditions, which are normally associated with hunger conditions, it takes the hint and phototropes just as though it were hungry. For a hungry man, a cook-shop window has an irresistible attraction, whereas to the well-fed person it may offer no seduction, or even be repulsive: nevertheless, "si par impossible" the odour which emanates from it is very agreeable, the well-fed man may deign to sniff.

Although the science of the physiology of form, as Prof. Klebs—one of its botanical pioneers—states, has not progressed beyond its initial stages, yet it is already strikingly emphasising the importance of nutrition, and therewith, as I contend, the still more fundamental importance of

Bio-Economics. I shall have plentiful occasion in the following pages to demonstrate the truth of these contentions.

The gastronomic triviality at the end of the above passage may, in the meantime, serve as an illustration of what a yielding to bad habits may in the end accomplish by way of causing loss of dignity, of association, and of "status." In human society, as in nature, individuals are most generally attracted by that which they have made their attraction—"Du gleichst dem Geist den du begreifst"—or, at any rate, attractions are qualitative. "Eating," as Samuel Butler would say, "is a mode of love; it is an effort after a closer union; so we say we love roast beef." Hunger is not satisfied by quantity merely, but by quality; although inferior quality is frequently required by cravings of an undesirable kind. There are two kinds of hunger—the physiological and the pathological hunger. The former results from "work," and its satisfaction generally stimulates further "work," which is more than can be said of the morbid kind of hunger, which is that of the pampered and "well-fed," and lacks that regularisation and standardisation which regular work alone can supply. Once a concession is made to the "seductive smells" of forbidden fruits, this is apt to lead further in the direction of morbidity and degeneracy.

The noblest races of organisms have shown a most remarkable survival of discriminative behaviour as regards feeding habits, and their success can be shown to be associated and correlated with this constancy of good habits in this respect. It is by proper "cross-feeding" habits and by these alone, as I have been at some pains to show in previous volumes, and as we shall presently see confirmed by the case of plant-animals, that progressive evolution can be successfully accomplished. The opposite mode, "in-feeding," is not only as fallacious as is perpetual in-breeding, but it produces in the long run as deleterious effects as sexual transgressions, and certainly reacts unfavourably on the evolution of sex. And this I

believe to be the greatest lesson for contemporary humanity to derive from evolutionary studies.

That primitive symbiosis—like primitive civilisation—entails a certain amount of restraint, and at least some mutual forbearance, may be gleaned from the fact of the occasional phase of abstemiousness exhibited by *Convolvata*.

Though kept for days in pure sea-water till any ordinary marine animal would be ravenous, an adult *C. roscoffensis* makes no attempt to ingest any food-substances which may be added to the water. "Though tempted with diatoms, green algæ, starch grains, oil drops, milk, or lamp-black, it remains with its capacious mouth so pursed up as to be invisible, and refuses to ingest any solid food whatever. . . . Normal *C. roscoffensis* in its natural state does not refrain from food because it cannot swallow, but because it does not want to eat."

This "fasting" habit is, however, only temporary. The animal can afford to exercise some restraint *vis-a-vis* the biological environment because it has adequate biological (symbiotic) providers within, and it can afford this precisely in so far and so long as it duly conserves these symbiotic providers—a number of green algal cells—which it has adopted in its domestic economy.

In order to elucidate the cause of this occasional "strange abstemiousness" of *Convolvata*, Prof. Keeble's explanation has recourse to what he terms "the commonplaces of plant-physiology."

I propose to deal with his explanation at some length, being convinced that vital and not yet recognised principles of Bio-Economics are here concerned, and that the whole matter will thus be lifted far above the level of the common-place. This is what the eminent Botanist has to say:—

Green plants do not take up solid food: they manufacture it. From inorganic substances, water and carbon-dioxide, which are absorbed from without, the green cells of plants manufacture sugar. This process, which is preliminary to nutrition, is termed by botanists photosynthesis, since the energy required for the manufacture of the

carbohydrate (sugar) is derived from the radiant energy of light. The green pigment, chlorophyll, which is associated in the green cells of the plant with specialised, granular bodies called chloroplasts, absorbs light, and in some way, as yet imperfectly understood, this radiant energy is utilized by the protoplasm of the chloroplasts in the manufacture of sugar. The plant possesses also the power of synthesising yet more complex substances. Besides carbohydrates such as sugar, which consists of carbon, hydrogen and oxygen, the plant prepares synthetically its own nitrogenous food-substances, the proteins. Though next to nothing is known of the details of protein-synthesis as carried on by the plant, this much is known, that the nitrogen contained in the proteins is derived by the green plant from inorganic sources, chiefly from nitrates which are absorbed in solution from the soil or water in which the plant is growing. Having thus manufactured its food-substances from raw, inorganic materials, the plant is free to feed upon them either to build up and repair its living substance (protoplasm) or to convert them directly or indirectly into substances (secretions) which enter into the composition of its tissues. Thus, for example, from the photosynthesised carbohydrate, are derived the cellulose substances which form the enclosing shell or cell-wall within which is contained each individual mass of protoplasm which we call a cell or protoplast. But besides serving such constructive purposes, much of the manufactured food-substance, particularly the carbohydrate material, is used for respiratory purposes, that is, for supplying the energy wherewith the plant does the work of living. By inducing compounds like sugar to unite with oxygen, their decomposition and oxidation are effected, with the result that energy is liberated and simpler substances, *e.g.*, carbon-dioxide and water, are produced. The liberated energy serves for the performance of the work which the living plant must do, and also, converted into heat, contributes to maintain the temperature of the plant's tissues at a proper level. The surplus of carbohydrate and of protein not used for constructive or respiratory purposes the plant puts by for future use. The starch, oil and nitrogenous substances contained in seeds, tubers, and other storage-organs of plants represent this reserve food-material.

The power possessed by the green plant of manufacturing food-materials in excess of its immediate needs is the lever which makes the whole world of animal life to move. For the animal has no such synthetic powers, and yet it requires the same food-substances as the plant. Hence it is constrained to take them from the plant. The aphorism "all flesh is grass" is no mere figure of speech, but a terse statement of truth.

The facts of the wonderful and partly still secret powers of manufacture possessed by plant protoplasm may be

commonplace from a laboratory point of view, but they are of special significance from a bio-economic point of view, although this has never been sufficiently demonstrated. Plant protoplasm represents the earliest labour, the earliest manufacture, the earliest surplus, *i.e.*, capital, in the organic world. But for this miraculous economic power of plant protoplasm (and its associated "good" character, from the point of view of Bio-Economics), organic life as we know it would have been impossible. Previous to nutrition there is work, *i.e.*, photosynthesis—whoso will not work neither shall he eat, is as valid in the biological as in the human sphere—nor has the organic world ever been able to dispense with this salutary arrangement or been able to allow any of its members to transgress it with impunity. True, the energy required in photosynthesis is largely borrowed from the sun (and that may have its own cosmological meaning), but it does not relieve any member of the biological community from the necessity of bio-economic contribution. All have to borrow occasionally, and all have to make good in one way or another. The way in which the radiant energy of the sun is utilised by plant protoplasm in the manufacture of sugar—previous to nutrition—remains for the present as mysterious as the fact that in the evolution of consciousness experiences are registered "within." Plant protoplasm also possesses the secret of protein-synthesis and, *mirabile dictu*, the wisdom of storing some of the results of its surplus labour (capital) for future (bio-economic) use, faculties not only wonderful but indispensable to the progress of the organic world. Though it is emphatically true, however, that the animal is particularly dependent on the labour of the plant, it is nevertheless nonsense to pronounce the aphorism "all flesh is grass" as no mere figure of speech, but a terse statement of truth. It seems astonishing that so acute an analyst as Prof. Keeble should attempt with such levity of argument to dispose of the necessity to grapple with the most important economics underlying the phenomena of animal dependence on plant labour, and the

relations between animal protoplasm and plant protoplasm. Nor is it accurate to say that the animal requires the same food substances as the plant. It certainly does not require the same raw material as the plant; it only—though very indispensably—requires some of the finished products which the plant has to offer in virtue of its position in biological symbiosis.

The aphorism, if it is to be interpreted otherwise than in the scriptural sense, can only mean that without the labour and the capital of the green cells and their wonderful bio-economic adequacy, there could have been no flesh. But flesh is not for this reason literally grass, nor, fortunately, are the two substances interchangeable. An ox could teach us better, for it would not accept flesh as a substitute for grass.

Moreover, in point of literal truth, such vegetable reserve food-material as mentioned by Prof. Keeble, *e.g.*, starch, oil, and nitrogenous substances contained in seeds, tubers, and other storage-organs of plants, are well capable of building up and maintaining (animal) "flesh" without any need of grass.

Nay, it stands to reason that *it is to the advantage of the animal to adapt its wants to the actual reserve-products of the plant rather than habitually consume those indispensable green cells which are the very foundation of all organic wealth*. Nor can any organism afford to transgress for any length of time against the principle of bio-economic utility which is here involved, and which requires mutual give and take and mutual forbearance. *Nunquam aliud natura, aliud sapientia dicit*. This, in my view, is absolutely fundamental.

That the animal, by transgressing, by becoming a "Pflanzen-Raubtier," for instance, is apt to kill the goose that lays the golden eggs is well known in practice, from the case of certain ruminants browsing too closely and destroying the vegetation of a whole district, and is also borne out, as we shall presently see, by the case of the plant-animals under consideration.

That *disaster must inevitably follow all kindred transgressions on the part of animals, whose main reliance must*

always be on the work and, more particularly, on the surplus products of the plant kingdom, I have been at some pains to point out in previous volumes.

The fact that plant and animal are physiological and bio-economic complements itself, indeed points to a common origin, as Darwin has already suggested from analogies of descent. We may take it that at one time in the common progenitor the respective units stood in a relation of reciprocal differentiation to one another, much in the same way as the relations between the organs of the body, or between the two sexes.

For aeons of time, we may believe, they were thus enabled to gain experience in mutuality and in (unconscious) co-operation. The better the vegetable part functioned in providing free oxygen and other reserve material, the better the animal part could function in setting free carbon-dioxide, in restoring certain nitrogenous products, and in evolving new substances for future mutual use. To be eternally providing not only for the present but also for a more glorious future, is quite as much a feature of the eternal giver, which is the plant, as is its much-talked-of passivity. Finally, in the evolution of the plant-animal, with increasing specialisation and differentiation, we may assume a separation of the partners to have taken place, much the same again as in the case of the sexes. The separation, however, is merely superficial, and we need to bear in mind that essentially every animal remains a plant-animal and every plant an animal-plant. Both are to increase the efficiency of reciprocal arrangements though separate. When separation came it only meant that both partners had qualified for work in wider spheres.

The primordial bio-economic and combined physiological relations essentially continued the same and remained as indispensable as before. With greater opportunities there arose greater possibilities of excess, and, organisms being physiologically frail, they have usually fallen victims accordingly.

Thus we have, indeed, the antithesis indicated by Tennyson—

Evolution ever climbing after some ideal good
And Reversion ever dragging Evolution in the mud.

The constant danger of excess and of reversions from good habits painfully attained indeed has not been left altogether unprovided for by careful Mother Nature. This entailed eventually a multiplicity of safeguarding contrivances, as we actually find them in the physiological economy of both plant and animal. We may thus assume that in the normal course of evolution the plant-animal partners grew with their greater purposes, as a man grows, according to Schiller, "mit seinen groesseren Zwecken." The physiologist would say that structure becomes increasingly modified with reference to the larger functions to be discharged.

To represent such avowed physiological (and, as I have shown, bio-economic) complements as if they existed only for purposes of their own ("Selbst-Zwecke"), and to slur over their vitally important (symbiotic) food-relation with cheap and frivolous aphorisms seems hardly worthy of an eminent scientist.

Muesset im Naturbetrachten
Immer eins wie alles achten.

For various reasons, which it would take too long to detail here, Prof. Keeble is driven to conceive of *C. roscoffensis* as an animal which lives like a plant; in other words, as a plant-animal, and that the green cells which form such a prominent tissue in its body possess the same secrets of manufacture and of photosynthesis as those possessed by green plants.

"A similar apparent total abstinence," he says further, "has been recorded in cases of other animals which contain green or yellow cells not unlike those which occur in our plant-animals. Thus no food has been seen in the bodies of certain adult *Radiolaria*, *Ciliata*, *Hydrocorallines* and *Madreporaria*, and in all these animals from which remains of food are absent, coloured cells are present. Hence the natural inference has been drawn that such animals subsist on the food-materials manufactured synthetically by their green or yellow cells."

There is, however, an important proviso to be borne in mind before it can be assumed that *Convoluta* presents a case of genuine or progressive biological symbiosis.

When referring to the abstemious habit of *C. roscoffensis* we were careful to state that it is the mature animal which does not take up solid food. As a matter of fact, from the time of hatching to the period of maturity, *C. roscoffensis* feeds, and feeds voraciously. Indeed, its catholicity of taste is remarkable. Diatoms, unicellular algæ, spores of various kinds, and, in the absence of more nutritious substances, grains of sand are swallowed with avidity. Arrived at maturity, it ceases to ingest solid food-substances. As old age comes on, it begins to feed upon its green cells. Groups of such cells in all stages of digestion, and varying in colour from yellowish-green to brown, may be seen lying in large vacuoles in the central digestive tissue of the bodies of old specimens of *C. roscoffensis*. Thus, though, as we shall see presently, the green cells of *C. roscoffensis* play an all-important part in the economy of that organism, they are not the sole purveyors of nourishment to it. Throughout a considerable part of its life, *C. roscoffensis* is able to help itself to the solid food supplied by the microflora and fauna of its environment.

Unlike *C. roscoffensis*, its ally, *C. paradoxa*, knows no abstemious fits. Throughout its life it is a glutton.

The abstemiousness of *C. roscoffensis* is thus seen to be only temporary, a fact which reflects rather unfavourably on the claim of symbiosis, or, at any rate, renders it necessary to qualify the term. Nevertheless, the fact that this abstemiousness, so long as it lasts, is based on the efficiency of *Convoluta's* own "garden" of green cells in providing supplies is significant enough.

Prof. P. Geddes has demonstrated that the green cells of *C. roscoffensis* are capable of photosynthesis, and their green pigment is spectroscopically identical with the chlorophyll of green plants.

That the products of the photosynthetic activity of the coloured cells are available for the nutrition of the animals which contain them has also been demonstrated. Prof. Keeble suggests that the appearance of yellow-brown cells in *C. paradoxa* recalls, in this respect, that of cells of a mammary gland in its active stage. This analogy is interesting and

important from many points of view. Whilst pointing again to the similarity between the phenomena of sex and those of nutrition, it emphasises more particularly the importance I have attached to "love-foods." The vegetable cell is capable in the right season of manufacturing, of secreting and retaining the proper kind of food-material for the animal, much the same as the mammary gland is capable of doing in the proper season for purposes of reproduction. "Every plant in the world," as Henry Drummond says, "lives for others; it *sets aside* something, something costly, cared for, the highest expression of its nature. The seed is the tithe of love, the tithe which nature renders to man."

A particular significance attaches itself, therefore, to the seasonable productions of the plant. We may conclude that, like those of the human mother, they are particularly valuable at those periods when both mammal and plant are most prepared to give of themselves and in fullest measure in order that the community may reap the benefit. The productive powers of a plant, like those of a mother, cannot be expected to be of the same efficiency at all times nor to be tolerant of perpetual abuse. Again, we must conclude that the necessities of the case require periods of recuperation on the part of the benefactors and adequate restraint and reciprocal services on the part of the benefitted, *i.e.*, genuine symbiosis, *i.e.*, co-operation between complements.

If the mammary gland is indeed foreshadowed in the mutual altruistic arrangements of very primitive organisms, its gradual perfection has, no doubt, been due to the same reciprocal methods becoming increasingly perfected notwithstanding physical separation. Our difficulty in realising this truth is due to the fact that the originative factors occurred in the dim past and are, therefore, too remote for our vision, and, further, to the great complexity of the higher organisms and our ignorance of the true causative factors of form-production, and in particular of symbiogenesis. (Both *C. roscoffensis* and *C. paradoxa*, by the way, are hermaphrodites.)

It may be that there has been, as Prof. Bergson suggests, an impetus of evolution, an immense impulse behind life to climb higher and higher, to run greater and greater risks in order to arrive at greater and greater efficiency, something that ever seeks to transcend itself, and, it may be, something that partakes of the nature of consciousness. But whilst this remains problematical, one thing is certain, viz., that without this perfecting of mutuality and co-operation in the organic world as foreshadowed already by the most primitive of organisms, the long ascent of life with which we now stand face to face would not have been possible.

Although Prof. Keeble shows that in *C. roscoffensis* the photosynthesised sugar streams away as such to the colourless cells of the animal, only the surplus being stored as starch, and that this phenomenon has its parallel in the fact that trees, for instance, similarly elaborate, store, and (in due season) yield their manifold productions (starch, oil, fat, etc.), he shrinks from drawing any bio-economic implications. To him apparently the animal merely helps itself, *i.e.*, steals the products of the life-energy of some plant to supply it with the dynamic leverage for its activities. Yet if, as he contends, the relation between the coloured chlorophyll-containing cells, and the animal tissues in the *Convoluta* presents "the closest parallel with the relation which obtains between the green and non-green cells of any chlorophyllous plant," then surely it should not be a far cry to the proper recognition of that complementary interaction, that symbiosis between animal and plant, which on a grand scale obtains in the organic world. The only difference is that we have in the wider and more complex biological symbiosis a physical separation of the partners, whilst in the more primitive local and domestic instances of symbiosis the partners remain closely united. But this is exactly on a par with sexual separation, and certainly should not perplex a biologist. It is surprising how few biologists can rid their minds of the prejudice that

only local attachment can constitute a case of either symbiosis or parasitism. They seem to be obsessed by definitions.

Wer will was Lebendigs erkennen und beschreiben
Sucht erst den Geist heraus zu treiben,
Dann hat er die Theile in seiner Hand,
Fehlt, Leider! nur das geistige Band.

It is well to investigate the mechanical streaming of food in *Convoluta* from the coloured to the colourless (animal) cells. But it is equally important to recognise that this is due to the bond of symbiosis, and that it is the identical bond which unites all organisms.

As I have now drawn a distinction between local (domestic) symbiosis and more specialised biological (bio-economic) symbiosis, it may be as well before proceeding with the study of *Convoluta* to dwell a little longer on a consideration of the former, particularly with a view to elucidate more fully the universal import of symbiosis.

Prof. Keeble's work on plant-animals has already stimulated a practical botanist, Mr. H. C. Davidson, to reconsider the subject of the nature of plants in the light of symbiosis. In a contribution to the *Contemporary Review* for September, 1913, he submits that a plant is not a single individual, but a community of individuals, gathered together in a state of symbiosis. The associated individuals he proposes to call "plantagens." Their association is for the common good, and when thus united higher results are produced than when the partners start growth on their own account and irrespective of the common good.

Symbiosis is generally defined as a physiological partnership between individuals of different species. But, says Mr. Davidson :

The possibility that it may occur between individuals of the same species, though a much more likely phenomenon, seems to have been overlooked. Every plant above the simple cell is not, as is generally supposed, an individual entity, but in reality a group or family of individuals associated within a common protecting envelope, the bark, and upon a common root for the common good. . . Each of these individuals

becomes first discernible by the eye in the bud stage, though there is obviously an earlier stage. Each is capable of leading an independent existence. It may be separated from the rest of the community, and if it is placed in a suitable environment, and provided with suitable food, it will continue to live and to perform its natural functions.

Evidently symbiosis cuts deeper than has hitherto been supposed, and evidently domestic and biological symbiosis are, at bottom, one and the same thing. Evidently, again, co-operation, however unconscious, fundamentally underlies all organic life. There is no miracle about form-production! It is due to individuality, to the work and the co-operation of individuals. If intelligence, however incipient, was concerned in the (symbiotic) integration of form, those Greek philosophers (who forestalled so much of modern science) who held that Mind formed the Body and that it was wrong to say that the mind was in the body: the body being in the mind, may not have been far wrong. There is no miracle about the fact that a bit of a twig sometimes is able to reproduce the whole plant! "It cannot do so unless there are buds on it; they may not always be visible to the naked eye, but there they are; without them it must die." In other words, again, reproduction of form (heredity!), like its original production, depends on individuality, itself dependent upon values accumulated by symbiogenesis. The bearers of these values in the case of plants are the plantagens. We can now better understand the significance of Prof. Klebs' remarks concerning "the inner world" of organism, and if, as he says, it is on this inner world that the environment exerts its influence, and that the importance of the "inner world" increases with the degree of differentiation, we are again justified in concluding that it is primarily work and symbiosis which are responsible for the production of form and of evolution.

By tracing symbiosis more profoundly than has hitherto been done, we thus arrive at a clearer conception of the most common modes of plant-reproduction. It is, on the one hand, symbiotic specialisation, with sacrifice of the freedom and

independence of the comparatively savage life for the restraint—but eventual higher freedom, security and success—of the social life which causes the division of plantagens into neuters or males and females; and it is, on the other hand, the necessity of bio-economic symbiosis that causes species as a whole to persist in their main course—equally one of adaptation to higher needs and equally deriving its glory from subservience to higher ends. Prof. Klebs states with particular emphasis that “it is characteristic of a species that it always exhibits a constant relation to a particular environment.” The interpretation now becomes easy in the light of our bio-economic principle requiring specialisation and reliable character* from all organisms for purposes of work, symbiosis, and symbiogenesis. Although the same eminent experimentalist states that the discovery of the internal processes of the cell produced by external factors has yet to be made, yet we can gauge from his own results that experimental morphology is already calculated to support the symbiogenetic view here put forward for the first time. He states: “When a bud is produced on a particular part of a plant, it undergoes definite internal modifications induced by *influences of other organs, the activity of which is governed by the environment*, and as a result of this it develops in a certain direction; it may, for instance, become a flower.” (Italics mine.) Clearly the success of the bud depends in part on the degree of domestic and in part on that of biological symbiosis, both of which, of course, stand in close interaction.

The same writer points out that “experiments show that in certain cases, if the efficiency of roots and leaves *as organs concerned with nutrition* is interfered with, the production of flowers is affected, and their characters, which are normally very constant, undergo far-reaching modifications. . . .” He also states that as regards flowering-plants, in the case of

* “Character,” says Huxley, “is the sum of tendencies to act in a certain way and is often to be traced through a long series of progenitors and collaterals.

the cells in a growing apex, possessing all the latent possibilities of development, "which of these possibilities becomes effective, depends upon the reaction of the external world transmitted through *organs concerned with nutrition.*" (Italics mine.)

Economic (dynamic) action and reaction in the web of life "carried on" (transmitted) by properly constituted "agents" (organs) "engaged in" (concerned with) the "work" of "production," "distribution," "utilisation," "capitalisation," "consumption" (nutrition), is thus exhibited as the cause of all changing forms and characters.

Normality and constancy in this inter-play of forces and in the resulting forms and characters (unit or general) are determined by the degree of symbiosis—domestic and biological.

The "asexual" method of propagation so common among plants does not appear to support the conclusion that every somatic cell possesses the full symbiotic potentiality of the species to which it belongs. The asexual is in reality but an inferior sexual method, an inferior sexual symbiosis necessitated by certain conditions of existence. Asexual, like sexual, reproduction is due to the presence of individuality, though for some reason or other less efficiently co-operative than in the case of sexual reproduction. Because the lower organisms are more loosely compounded of individuals (and for that reason are the "lower") than the higher, it does not follow that the difference between them is other than of degree. The main point is that we have in each case a symbiosis, where all participants have their respective duties to perform (have to give of themselves in some shape or form). Some give as neuters satisfied with asexual propagation, others—when a higher degree of symbiosis is reached—as proper sex individuals.

In the sexual reproduction of plants some of the plantagens, in one stage of their existence, appear as flower-

buds. Like those plantagens which, owing to various circumstances, can only attain to asexual reproduction, "they also are capable of leading an independent existence for a time, but owing to the fact that they require for their exacting duties a large amount of food in a highly condensed form, it is not so easy for them to mature their seeds where they are thus isolated as it is when they are associated with the rest of the community, the workers or neuters, who help to feed them."

The attainment of sexual reproduction, and all that it implies, is thus seen to be a matter of attaining a relatively high character, *i.e.*, a high degree of (unconscious) co-operativeness and symbiosis. Such developments are generally associated with a high degree of general productiveness and of status. The actual position of a plant in the scale of evolution is according to its productiveness of values. It is to the sexual method, moreover, that we primarily owe our "love-foods." No wonder the same method has been recognised by various writers as productive of progressive variations and of progressive evolution. Weismann's "amphimixis" theory is an example.

To produce the "large amount of food in a highly condensed form," indispensable, according to Mr. Davidson, to the flower-buds in the discharge of their "exacting duties," is no small matter! Especially if we add the consideration that in view of the fact that every plant is engaged in symbiosis with the animal kingdom, it has to provide a double adequacy of nutrition—domestic (racial) and bio-economic (inter-organic). No wonder an efflorescence of sex involves many onerous duties, and requires the complete and unobstructed co-operation of all the parts concerned. No wonder the sexual instinct is a very profound one! The significance of sex is enhanced if we remember that the value of the sexual process is not only instrumental in bringing about progressive evolution through amphimixis, and the conservation of all that is best within a species, but that it concurrently stimulates the performance of indispensable bio-economic duties.

In my little work on *Evolution by Co-operation*, I have already pointed out that reproduction itself enters the service of general production as instanced in particular by "love-foods," *i.e.*, the bye-products of plant-reproduction, which as exchangeable surplusage and in virtue of their high adequacy as food for the animals, are of such enormous currency value in organic civilisation. Here, where the value of symbiotic production is becoming more especially apparent, it is incumbent on me to expand on this subject of "love-foods" which has already been mentioned in connection with the analogy between secretions by *Convolvulal* coloured cells and those of the mammary gland. I have there already hinted that sexual symbiosis in the plant is productive of "love-foods" which are in turn of high significance in biological symbiosis.

"Love-foods"—milk, the date, the raisin, the banana, and the bread-fruit, the locust and the honey, the eggs, the grains, the cereals and the legumes—constitute the great bulk of the foods of the world. If Prof. Keeble states that the food-material manufactured by the plant in excess of immediate needs is the lever which makes the whole world of animal life to move, this is pre-eminently true of "love-foods." "Love-foods" are not only responsible for mechanical energies, but also largely through many subtle qualitative influences for the physiological and psychological elevation, *i.e.*, for the evolution of the animal. In the joint evolution (rise of type) of plant and animal, a place of first importance must be accorded to "love-foods." It is greatly due to their increasing effectiveness and adequacy, I assert, that eventually the pace of evolution became much quickened—a phenomenon otherwise appearing as extremely puzzling.

Herbert Spencer already emphasised as significant the fact that whereas in other parts of the plant the genesis of heat is extremely small, those portions only, as flowers and germinating seeds, in which considerable oxidation is going on, have a decidedly raised temperature—an indication that

physiologically also the plantagens here concerned are on a higher level than other parts.*

"Love-foods" are thus seen to be specially favourably circumstanced and equipped for special bio-economic and bio-chemical effectiveness. We have seen how the flower-bud, in order to achieve its efficiency in the discharge of its manifold onerous duties, has in turn to rely upon every shred of co-operation and of consideration that it can obtain from all those concerned—be they plantagens or animals—in the preservation of its valuable species. In the last analysis, therefore, the high bio-chemical adequacy of "love-foods" is compounded by strenuous symbiotic service, and rests securely on the bio-economic adequacy of such service. Bio-chemistry has proved that "love-foods" in one shape or other, by their possession of subtle and highly complex substances, are of peculiar adequacy, and are indeed qualitatively indispensable to animal economy. This discovery bids fair to revolutionise all previous notions concerning nutrition.

"Vitamines" is the name given by Dr. Casimir Funk to these newly-discovered bodies.

They are nitrogenous and of highly complex structure (e.g., the formula of one is $C_{26}H_{20}O_9N_4$); they are indispensable for life, and no diet is complete without them. If the brain, "one of the three legs of the tripod of life," is starved by a vitamineless diet, troubles of all kinds—called by Funk *deficiency diseases*—arise, and these may end in death. The muscles dwindle away, the nerves degenerate, and heart and bone troubles result. Their absence is a predisposing cause of tuberculosis. Vitamines are found in plants, and especially in their seeds. So far as is known at present, animals are incapable of making them. Animals, however, obtain them by feeding on plants. Thus

* Dr. H. M. Vernon in a very interesting contribution to the "Bio-Chemistry of Respiration" ("Science Progress," Oct. 1914), infers that, generally speaking, need of oxygen seems to increase *pari passu* with increasing complexity of chemical and morphological organization, and further, taking an organism as a whole, its oxidasic power varies with the magnitude of its respiratory *exchanges*, which, in my opinion, is further illustration of the fact that the very important bio-chemical (positive) factors of evolution depend for their adequacy and efficacy on bio-economic (symbiotic) activities (work, services, *exchange* of services, co-operation), for the needs and powers here concerned are primarily connected with purposes of symbiosis—domestic or biological. Respiration is subservient to a perfect round of (bio-economic) mutual services. The oxygen liberated by strenuous and symbiotic plants in turn serves many symbiotic purposes (of animals and plants alike) in the web of life.

vitamines occur normally in meat, fresh milk, and yolk of egg. They are soluble in water, and insoluble, mostly, in ether. They are thermolabile, and are destroyed by exposure for ten to twenty minutes to a temperature of 120-130C., as well as by extreme dryness. Thus cattle may, following on a long drought, suffer from a vitamineless fodder.

Funk regards vitamins as the mother-substance of ferments and hormones, and of vital importance to the thyroid and other ductless glands. It is thus evident that the diet standards of the text-books must be revised in the light of their discovery, which throws a flood of light on the milk and other food problems. White flours and corn flours are deficient foods, because the vitamins have been removed in the milling process.

Wherever any cereal, robbed of its aleurone or vitamin layer, forms the chief food of a people, there a deficiency disease appears. Rice is eaten by more people than any other grain in the tropical regions of both hemispheres. The marked increase of beri-beri caused by eating *polished* rice, claiming thousands of victims yearly in Japan, etc., coincides with the replacement of the primitive whole-grain stone-milling by the modern steel roller. The United States Government has already made the polishing of rice in the Philippines illegal. Indian corn (*Zea mais*) is largely eaten in North Italy, the Balkan provinces, the southern part of the United States, Brazil, etc. In all these countries pellagra, which affects the skin, digestive organs, and mental powers, is prevalent. The disease could be stamped out by adding to the diet potatoes, one of the cheapest and most practical sources of vitamins. Though the tax of 32s. 6d. a ton on potatoes has been removed, the U.S. Government has at the same time closed its ports to European potatoes, as a precaution against the introduction of potato diseases, such as Spongospora, though pellagra is on the increase, and American potatoes are becoming dearer. Rickets, scurvy, osteomalazia, etc., are also deficiency diseases caused by the use, as the main articles of diet, of such vitaminless foods as sterilized milk, condensed milk, cornflours, starch and sugar. The mixed diet of most people protects them from deficiency diseases. Vitaminous foods are fresh milk and (though less rich in them) pasteurised milk, whole grains, potatoes, carrots and other fresh vegetables, lime and other fruit juices, beans, peas, lentils, and the like, meat, beef-tea, barley-water, yeast, and apparently cod liver oil. The discovery of vitamins leaves the vexed question of the relative values of white bread, standard bread, etc., where it was, as the heat of the oven, far above that of the autoclave in milk sterilisation, probably destroys the vitamins of the wholemeal bread. (*Nature*, 12/3/14.)

(This latter inference, however, seems to be contradicted by other investigators. Thus Prof. Leonard Hill stated in *The Lancet* that the vitamins present in wholemeal wheat flour are not destroyed by baking.)

Vitamins thus occur especially in seeds ("love-foods"), and it appears that animals are incapable of making them. It is the aleurone layer of the endosperm of a grain which chiefly contains these newly discovered bodies. There is a notable endosperm—that of Indian corn, which has been shown to arise by a process very similar to that which gives rise to the embryo itself. The hereditary qualities, moreover, of endosperm and associated embryo are said to be exactly alike. Hence, we see how such food material partakes of the vital characteristics of germ-cells and to what an extent the plant gives of itself in its "love-foods." We are justified in speaking of "nutritional amphimixis" (see my *Evolution by Co-operation*) to denote the indispensability of this biological symbiosis, and its close analogy to that symbiosis which is represented by the co-operation of the sexes. We see that the best food material in the world is "matured" and requires "maturation" (involving concomitant and correlated evolution) on the one hand, and adequate forbearance and assistance on the other, just as much as do germ cells. "Love-foods," hence, are superior to other foods in somewhat the same way as germ cells are superior to somatic cells, viz., in containing the elements of continuity.

At the point where we digressed from the consideration of *Convolutal* symbiosis to consider Mr. Davidson's plantagen theory, it will be remembered that Prof. Keeble already hinted at the (domestic) symbiosis existing within the cell-community that constitutes an individual plant.

Mr. Davidson has merely carried the idea of domestic symbiosis one step further with his postulation of plantagens founded on his practical experience of plant propagation. Although he even goes further in emphasising many striking similarities of behaviour between plant and animal individuals

hitherto but scantily considered, but in reality showing the difference between them to be primarily one of bio-economic position, he fails, like Prof. Keeble, to take the further step that would bring him to biological symbiosis. This failure is mainly due, I believe, to the inability to account adequately for the bio-economic and qualitative factors of nutrition. He tells us that the plantagens in so far as they represent (economic) individuals can move and do move like animals. "That is to say, they change their position—it may be by some power inherent in themselves, or it may be simply by the intervention of the multiplying somatic-cells. There is a definite order in their movement—a regularity both in the length and the direction of their journey—which suggests that the mobile power is in themselves."

The imaginary passivity of plant-life thus receives a rude shock. At any rate the plantagens must be supposed to be sufficiently mobile and alive to look after their business. Butler's sarcasm seems to be appropriate here: "If a substance does not succeed in making it clear that it understands our business, we conclude that it cannot have any business of its own, much less understand it, or indeed understand anything at all."

Maybe that one day we shall speak of the bio-economic co-equality of plant and animal, just as we now speak of the co-equality of the sexes.

When the plantagens eventually come to rest "they enter upon a new phase, each becoming an incipient bud, and developing a feeding and breathing apparatus, a leaf, by which means it is enabled to grow, and, under favourable conditions, to propagate its race and to make itself generally useful to the community."

If a plant is thus viewed as a community of plantagens it is "impossible to escape the conclusion that, comparing one stage in the existence of a plantagen with a similar one in that of an insect, the flower corresponds to the butterfly. The fact that both are more or less brilliantly coloured and beautiful in

form may not have much significance, but there are others which are of more importance. The plantagen, like the caterpillar, goes to sleep at the approach of winter, and in the flower-bud, as in the chrysalis, are provided the essentials for carrying on the race. In both cases, as soon as the winter's sleep is over, the final change comes swiftly—from the bud issues the flower and from the chrysalis the butterfly, the latter with its eggs to start the cycle afresh and the former with its seeds."

Mr. Davidson suggests that it would be unreasonable to ascribe these two series of extraordinary events to coincidence. "They must be similar effects produced by similar causes." Nor is the reason for the similarity far to seek when we find, as presently we are reminded, that ultimately the phenomenon is related with nutrition.

If a caterpillar is supplied with an abundance of suitable food and kept at a suitable temperature, it will not enter the chrysalis stage until long after its usual time, as, indeed, naturally happens in the case of certain wood-boring caterpillars which, surrounded by food and protected by its means from great variations of temperature, undergo no metamorphosis for at least two years; and if a tree is grown under similar conditions, the buds which it bears do not enter the stage which results in flowers—they merely increase in number. That is, the tree keeps on growing.

That a surfeit of food is apt to impede progressive sexual developments in both plant and animal is a fact I have been urging in all my writings. The above passage requires an addendum concerning this factor of surfeit, viz., that it amounts to a temptation of both plantagens and lowly animal types to slacken in symbiotic activity. Nutrition, in view of the fundamental fact of symbiosis, has an essentially remunerative aspect—the recompense for proper nutritional habits consisting in favourable bio-economic, favourable biochemical, and related physiological circumstances, as instanced by the existence and adequacy of "love-foods."

As soon as an organism becomes surfeited it is apt to lose its erstwhile internal (physiological) co-operativeness *pari*

passu with its external (bio-economic) co-operativeness. That the composing parts cease to work together as they used to do soon becomes obvious; what is less conspicuous, and therefore generally overlooked, is the simultaneous snapping of the external—the bio-economic—bond. We cannot be surprised to find that in conditions of surfeit the component parts of an organism—be they plantagens or other quasi-individuals (organs)—lack the stimulus for work, both physiological and biological.

Surfeit and “rich food” thus stimulate in the pathological direction. They are the very conditions and causes of parasitism, just as luxury brings social degeneration and carelessness about national welfare. It is notoriously hard “to argue with stomachs that have no ears.” The consequence is that the system as a whole cannot attain to a high position. *Noblesse oblige*, both physiologically and biologically, as we have seen in the case of the flower-buds. Inflation is the curse of a commonwealth, and a return to sobriety its cure. This, then, is the required explanation of the common cause which produces these similar effects.

Here, with a certain general resemblance, Mr. Davidson notes a difference. Whilst as the result of surfeit (or conditions equivalent to surfeit) the buds—unable to attain to pure sexuality under such obstructing conditions detrimental to co-operation—increase (asexually) in *numbers*, caterpillars increase in *size*. But, suggests Mr. Davidson, this is so only because the butterfly and the moth families propagate only sexually, and as soon as we go to families of a lower order which propagate asexually as well as sexually, the resemblance between insect and plantagen again becomes very close. As an illustration he gives the rose-aphis.

As this case is of the utmost importance to my bio-economic thesis, and as, moreover, it bears resemblances to the behaviour of the *Convoluta* that we are here considering, I hope that a somewhat lengthy quotation will not be considered unwarranted. We are told:—

In spring the wingless female, without the intervention of a male, starts at a terrific pace to propagate the species by a process which is known popularly as budding, and scientifically as parthenogenesis. It throws off living young in reckless profusion, and continues to do so for months. The young are soon able, also without the intervention of a male, to propagate in the same manner, as are the generations that follow in rapid succession, and in consequence the descendants of a single female would, but for the checks imposed by Nature and by man, in the course of a season cover an enormous area. As the summer advances, however, the rose-aphis, like *Convolvata roscoffensis* previously mentioned, feels the urgent need of a change of diet, and, unlike that animal, is able to get it by going farther afield, for it has for a brief period entered the pupal state and has emerged with wings. So it deserts the rose, on which it has hitherto lived, and flies to certain grasses, feeding on them for some weeks, and finally, after mating, returning to the rose, where it commences a wholly different method of propagation—by means of eggs. When we remember the effect that a change of food has on bees, converting an ordinary worker or undeveloped female into a queen capable of egg-laying, it is a fair inference that this is also the cause—or at least one of the causes—of the remarkable change in the structure and habits of the rose-aphis. In the brief sketch of the life-history of *C. roscoffensis*, we saw a similar sequence. So long as the animal was content with its usual food it merely continued to grow, but when it turned to other fare and devoured the cells within its body, it began to produce eggs, “the substance of which,” as Prof. Keeble tells us, “was supplied by those cells.”

What emerges is this:

Different modes of nutrition are responsible for different modes of propagation and for different forms and structures. This fact, as we have seen, is ultimately connected with bio-economic differences, *i.e.*, with differences of work. In the last analysis permanence and survival in the organic world depends on work as instanced by the value and indispensability of photosynthesis. Whether a particular organism—be it plant or animal—is to be stable and permanent, similarly depends on its continuance of work. Where depredation, surfeit, and parasitism take the place of work, the resulting organisation must become unstable. What is it, then, that constitutes “usual food” for an animal? That food, it must be answered (from the point of view of value and of permanence), which is obtained by work, *i.e.*, as a result of

adequate symbiotic services. The food gotten by dishonest living—though many species have contracted the predaceous habit and make dishonest gain their “usual food” and are apparently flourishing—is not permanently advantageous in any real sense. Hence there arises in due time—for purposes of health and of sexual reproduction—the requirement for a change of food, a longing for the “simple life.” A recovery is made provided the bad habits were not carried to the extent of “obligate” parasitism which means in-feeding so intense, fastidiousness so morbid, and loss of the sense of proportion so complete, that the way is barred to a return to a wholesome diet.

Both rose-aphis and *C. roscoffensis* show by their “urgent need of a change of diet” that they have already entered in varying degrees upon the path of retrogression—“dragging Evolution in the mud.” That parthenogenesis as here exemplified by the rose-aphis is a degenerate form of reproduction has long been recognised. It is based on the opposite methods of life to those which produce symbiogenesis. When the rose-aphis flies off to certain grasses to cease its career of indulgence on the rose and to feed instead on them, this is in order to restore a former condition of symbiotic normality by means of a tolerably normal mode of feeding which permits the re-acquisition of the power of sexual reproduction. We may take it that the aphis is not a pest on these grasses to the same extent as it is on the rose, and by being able to make the change it shows that it has not yet become as fastidious as obligate parasites which cannot change their host under penalty of death. The aphis thus purchases rejuvenescence by curbing its anti-symbiotic propensities and giving up conditions of surfeit. That *Convoluta* stands in like case we shall presently find. What similarities there are between aphis and plantagen, therefore, are in the last analysis similarities of instability and of a restoration of some stability by similar means, *i.e.*, by a return to moderation and proper conditions of symbiosis. Mr. Davidson contents

himself with registering and emphasising the connection between the alternations of "usual food" and "other fare" and those of sex in the various instances of metamorphosis, be they manifested by plantagen or by insect. As I have already remarked, he has no explanation to offer. The connection itself has already been pointed out by others, except that Mr. Davidson's plantagen theory adds a valuable factor, hitherto missing, towards the recognition of the underlying bio-economic principles. We see now why Mr. Davidson was driven to make his comparison of plantagens (in surfeit) with lowly orders of insects, viz., for the reason already stated, that he is there, where degeneration is of frequent occurrence, in reality comparing similar phases of bio-economic abnormality.

The case of the more stable higher insects and of the higher animals propagating chiefly sexually, like that of the higher green plants, stands on a different level.

There remains, as Prof. Keeble points out, a wide gap between the state of affairs in *C. roscoffensis* and that in the higher green plant.

"Sooner or later, *C. roscoffensis* destroys and digests its green cells, and none of them, nor any colourless representatives of the green cells, pass into the egg-cells; whereas the higher green plants provide for the future crop of chloroplasts in their descendants by transmitting colourless rudiments of the chloroplasts to their egg-cells."

The symbiosis between animal and plant partner in *C. roscoffensis* is thus retrograde and unstable as compared with the domestic symbiosis in the higher green plants, and this chiefly because it fails in biological symbiosis; neither *Convoluta* nor rose-aphis can obtain any abiding gains, can set up a permanent and mutually auspicious relation with the plants they exploit, or produce any bio-economic values, i.e., social or communal utilities, in virtue of this exploitation. Both require renewal by fresh "blood," the blood formed in dishonest living not being conducive to effective nutritional

amphimixis and to genuine viability. "They toil not, neither do they spin." They rely on new supplies turning up as by Providence; but they do not themselves cultivate and turn into pasture lands the soil from which they draw. Symbiotic in a sense the case of *Convolvuta* may be, but it is rather a one-sided and retrograde symbiosis to be distinguished from progressive symbiosis.

In progressive symbiosis the partial renunciation of their individual independence by the partners, be they plantagens or otherwise, favours the production of permanent physiological and bio-economic values. The seasonal rhythm with which the parasitic excursion of the rose-aphis recurs has a parallel in the seasonal rhythm of plantagen activity in a tree, but qualitatively speaking there is a great difference between the two.

The plantagens of the tree represent a case of vicarious sacrifice, both as far as the domestic and the biological communities are concerned. As Mr. Davidson says himself, if for the majority of the plantagens the bud stage is the limit, "they are merely humble workers, hewers of wood and drawers of water for their gorgeously-attired sisters, who flaunt their fine feathers in the sunshine." How can a similar degree of symbiosis be shown to exist in the case of "the worst pest of the garden" indulging in "reckless profusion" (of physiological capital) on the one hand, and in wholesale destruction of organic wealth on the other? The two cannot fairly be compared.

What is represented by Mr. Davidson as a mere gastro-nomic whim, or as a mysterious craving for a change of diet, is thus, in reality, a highly significant and deep-seated physiological and symbiogenetic necessity—exhibited by numbers of plants and animals—towards a reduction of surfeit and of depredation as a pre-requisite to the re-establishment of sexual reproduction. There is the case of the Rhine salmon and that of the Adélie penguins fasting during the breeding period. Many other examples occur among animals, as Prof. J. A. Thomson

informs me. There is also the case of the inflorescence of plants which requires frequently, as a pre-requisite, the diminution of the supply of mineral salts. It is almost as though, as L'Estrange already declared: "A squeamish fastidious niceness, in meats and drinks, must be cured by starving." Medical men, indeed, begin to see that at least an occasional meat fast is for various reasons an excellent thing. We may say that it has the effect of assisting towards a re-establishment of a tolerable degree of domestic symbiosis—both for ordinary physiological as well as for genetic purposes—in those cases where domestic symbiosis is in danger of becoming perverted by the particular organism's transgressions against the laws of biological symbiosis. The organism under these circumstances can rely for genetic purposes on racial capital (accumulated without depredation) rather than on the dishonest "gains" due to the change of habit from strenuousness to depredation. In the case of a typical in-feeder, the King Salmon (*Oncorhynchus*), the *misère physiologique* has become so great that the animal does not eat in fresh water at all and exhibits degeneration of the food canal. "The intestine and the stomach shrivel up and the mucous membrane degenerates." The reproductive nemesis is such that the fish die after spawning—generally before they reach the fourth or fifth year. "There is no return to the sea as in the case of our salmon." At the same time all such organisms seem an easy prey to numbers of parasites—in short, they exhibit all the symptoms of an intense "parasitic diathesis." Cases of indulgence, of course, are frequently connected with the rhythmical change of the seasons, but it is only a certain number of organisms that go to excess and run the risk of degeneration in a favourable season. Others remain unsurfetted and strenuous; nor do they exhibit any need for a drastic change of fare prior to reproduction.

Before starting on our digression concerning the nature of plants, we saw that in the case of both plants and of

plant-animals the carbohydrates manufactured in excess of their own requirements by the green cells are translocated to the colourless tissues and used by them as food-material. The streaming of this food-material is comparable to the interconnected movements of raw material and manufactured articles or capital (stored-up labour) along the highways of international trade, and that similar trade relations exist between plant and animal and in the organic world generally, and have persisted throughout evolution, I have already partly shown in my previous volume (*Evolution by Co-operation*).

If it is true that all later developments of animals and plants are based on a primordial plant-animalism, we may assume that with every progressive division of labour there went a possibility of further mutual enhancement, and, likewise, that the normal influence of the biological environment tended to favour the increase of efficiency rather than otherwise. The same favourable influence must have obtained for any particular qualification and character which provided scope for increased mutual aid and mutual advancement.

It is as the result of such deeply ingrained primordial instincts and needs of co-operation, based as they are on organic solidarity and organic self-preservation, that the foundations of organic progress were too deeply laid for the predaceous types to effect any lasting encroachments: "Und immer zirkulirt ein neues, frisches Blut." The new and fresh blood, as I have stated above, is the efficient blood resulting from adequate nutritional amphimixis and receiving ever new dynamic evolutionary value from the associated wholesome activities. Impure blood, on the other hand, flows increasingly in the channels of predaceous life and causes abnormality, precocity, monstrosity, and extinction.

Those animals which do not confine themselves in their food habits to just proportions and to the proper material—"love-foods" at the higher stages—thus become, in my view, eventually debarred from progress, and drift into blind alleys of evolution.

That under conditions of depredation and mutual plunder the plant cannot function as symbiotically and therefore as adequately as under conditions of mutual co-operation is as self-evident as it is also conspicuously apparent in nature. The energies spent by a plant in the production of poisons for self-defence—like the capital spent by modern nations for armaments—is at the expense of productiveness in other directions. With plant species destroyed in numbers by animal depredation and with many plants turning poisonous for protective purposes, animals in many instances have had to turn upon other animals until a fair equilibrium between plant and animal is again restored—such is “*der Fluch der bösen That.*” In the ocean, for instance, the quantity of plankton is held to depend upon the proportion that the destruction of algæ by physical and animal agency bears to their production, and if, as Prof. Keeble assures us, most marine animals are always ravenous, we may conclude that it is at bottom the lack of biological symbiosis which is a primary cause of unnatural and morbid craving which comes under the head of what I have termed a parasitic diathesis. Retrograde symbiosis leads to insufficiency of food-supply, with its subsequent temptations and necessities, and *conduit à la mort* rather than to genuine survival.

Just as a leaf detached from the tree is at once cut off from a supply of water and salts, and is deprived of the means of getting rid of organic substances which it produces and must consequently suffer considerable alteration of concentration—so an organism detaching itself from genuine biological symbiosis is gradually deprived of the possibilities even of fruitful interchanges with the biological community, and is certain to undergo such changes in its constitution as in turn to divorce its kind ever more and more from symbiogenetic progress, from the perennial plasticity of the truly symbiotic organisms.

I shall have to revert in a subsequent chapter to the matter

of alkaloid poisons, developed in self-protection by the plant, and the appalling potency of their action upon animal physiology.

We may now return with clearer vision to Prof. Keeble's exposition of *Convolutal* plant-animalism and try to understand what really happens when, in certain circumstances, *C. paradoxa* and, to a somewhat less degree, *C. roscoffensis*, exploit their coloured cells in a summary manner. The facts are:—

In prolonged darkness the yellow-brown cells, once their reserves of food-material have been extracted from them to meet the needs of the animal, are digested wholesale by *C. paradoxa*. If the water in which they are contained is altogether devoid of food supplies, the attack by the animal on its coloured cells occurs all the sooner. Even in the light, if external food supplies are withheld from *C. paradoxa*, a time comes when, although the yellow-brown cells are supplying it with photosynthesised food-materials as fast as they can under the difficult circumstances, it turns upon them—killing and digesting the goose which laid its golden eggs.

Microscopic examination of animals kept in prolonged darkness supplies evidence that the degeneration of the yellow-brown cells is not a mere decay within the body, but is the result of a true process of digestion exerted on them by the animal.

It is interesting to observe, in this connection, that if animals are brought, after a prolonged sojourn in darkness, into the light and supplied with fresh sea-water, yellow-brown cells make their appearance again in the bodies. As they grow and increase in numbers, the animals also begin again to grow.

So also in the case of *C. roscoffensis*, if the green cells fail to make their appearance in the body, the animals remain of microscopic size. If, on the other hand, the green cells appear, increase and multiply to form the characteristic green tissue, the animals begin to grow rapidly.

Thus in various ways it has been demonstrated that *C. roscoffensis* and *C. paradoxa* depend for their food on their coloured cells. Without them they fail to grow.

It is evident that the coloured cells are of enormous importance in the physiological economy of our plant-animals. In partial, in retrograde, or in genuine bio-economic symbiosis the wonderful properties and gifts of the plant

remain indispensable to the animal. Truly the summary exploitation of the coloured cells by the *Convolvata* amounts to killing the goose which laid the golden eggs! It can be done with a certain amount of regularity (though even so, physiologically, not with impunity) so long as a sufficient supply of free cells is always offering itself. Thus these primitive animals, instead of relying wholly and solely on biological symbiosis—which requires give and take—have managed somewhat retrogressively to obtain essential supplies of photo-synthesised food-materials by a kind of return to an ancestral mode of domestic symbiosis, which allows them both to supplement other supplies and to replace them at times by a less surfeiting and physiologically more suitable nutrition. It is a compromise which suffers from its one-sided nature and consequent lack of stability, a consortism (rather than a symbiosis) which is opposed to the main lines of evolutionary progress.

It is worth noticing, again, how in the case of both *C. roscoffensis* and *C. paradoxa* even a limited reliance upon the seasonal gifts, however ill-requited, of the green plant implies:—

(a) Extraordinary powers of resisting starvation;

(b) An astonishing degree of independence—an income which, though but for a time, renders predaceous and blood-thirsty departures (an intense “struggle for existence”) unnecessary;

(c) Proper bio-chemical material and stimulation for growth and (by providing the proper food substance for the eggs) for fertilisation, *i.e.*, for rejuvenescence and sexual reproduction.

But notwithstanding all these benefits, forbearance and return of service on the part of the animal are inadequate to set up such a genuine union as exists between the parts of a green plant. The association of cells in *Convolvata* fails to provide opportunities for the establishment of such mutual reproductive expenditure as would be required for the propagation of the union as a whole.

We are not justified, moreover—despite all these striking temporary benefits—in viewing the case of *Convolvata* as approaching a genuine biological symbiosis, but it rather seems to be a reversion from such. To take a true instance of symbiogenesis: I have shown in a previous volume (*Evolution by Co-operation*) that there is a significant connection between the considerable longevity of certain trees or shrubs—a factor generally connected with a relatively high amount of reproductive expenditure—and the peculiar adequacy of their productions (“love-foods”) for the higher animals—characterised in turn by their long periods of gestation and likewise by their readiness to cultivate and propagate their food-plants. On this symbiogenetic relation I shall have more to say later on.

Protracted gestation, longevity, symbiotic behaviour, mutual aid, and mutual toleration with security of life, high status, and general productiveness thus always go together in genuine biological symbiosis, as they do in the domestic symbiosis between the parts of a green plant. Hence genuine biological complements are like the parts of a green plant economically and physiologically belonging to one another, although physically separate. This it is vital to remember as the true relatedness thus disclosed constitutes in great part the mechanism of heredity.

I have at the same time been urging in a general way the significance of the cumulative effects of food upon the generative system, and now that the connection of nutrition with every important biological development is becoming increasingly apparent, it is well to elucidate still further this very important matter.

The comparative harmony and order of the reproductive life of the Mammalia, as is well known, are purchased by a considerable amount of reproductive expenditure. It requires the discharge of manifold and exacting duties and presents a case of *noblesse oblige*. And in this instance we can see how higher symbiotic needs have called forth new organs, and how

this must have been generally the case in evolution. We can also see how great a part must have been played by every form of protracted nutritional gestation in pre-determining new organs and new structures, for, as we have recognised, nutrition determines the degree of symbiosis and, hence, also the possibilities of metabolic response to all new and important factors affecting a species.

In the female mammal a considerable amount of reproductive labour and connected metabolic activity is deputed to an important gland—the *corpus luteum*—which, by means of chemical stimulation, controls (so far as we yet know) the uterine changes necessary for the attachment of the embryo in the early stages of pregnancy, and also incites the formative growth of the mammary glands.

As soon as the *corpus luteum* is formed, the mammary gland begins to grow. This growth is noticeably increased after the body is fully formed, a stage characterised by the presence of plentiful granules in the lutein cells. The gland secretes a substance of lipoid nature. It is present in a well-developed condition in the three sub-classes of the Mammalia, and it plays a most important part in the mechanism of reproduction. We have seen the connection between “love-foods” (with the implied degrees of symbiosis) and the mammary gland. Can we now deny—in view more particularly of the bio-chemical importance of the *corpus luteum*—that biological symbiosis, *i.e.*, an adequate symbiogenesis, must have been the pre-requisite of its origin and evolution?

The protracted ingestion of “love-foods” and of vitamins under genuinely symbiotic relations—increasing in adequacy and in abundance with every increasing degree of symbiosis—has, I believe, in course of time tended to build up the *corpus luteum* as a special organ to grapple with the more complicated problems of Bio-Chemistry offered by the higher forms. Its evolution has been no different from that of the mammary gland. It coincided with the perfection of symbiosis. In the last analysis, of course, it may be

said that everything is due to the plant, "l'éternel préparateur de la vie." That its productions and stimulative influences, however, are largely regulated according to animal behaviour is well borne out by the startling potency in the animal economy of the vegetable alkaloid poisons. The plant disseminates death or life to the animal world according to the degrees of symbiosis to which it is treated. Thus the plant (though, of course, unconsciously) discharges for the animal the function of providing the requisite chemical stimulations, much in the same way as we say the *corpus luteum* has deputed to it within the mammalian organism the duty of providing the essential chemical stimulation for the growth of the embryo and the formation of the mammary gland.

So, again, we saw that only where the wood-buds can perform their highest function is the flower-bud possible. Similarly, only where the plants can perform their highest work can the animals advance in physiological complexity. Thus, I maintain, does plant-evolution determine animal evolution, and thus it is that symbiogenetic differentiation alone conduces to life.

We can also understand why nuts, for instance, which are chiefly the products of trees or shrubs of considerable longevity, according to Dr. Wallace, are so largely eaten by mammalia and birds. We can now understand that such food must have been possessed of adequacy to stimulate progressive development whether through new organs or otherwise. We can also perhaps understand the reason why the sub-class *Monotremata*, though they possess *corpora lutea*, have not been able to equal the rest of the mammalian class in forming a placenta. They are largely "in-feeders," i.e., depending more exclusively on animal food, and are thus debarred from a proper, direct, and living relation with the plant, whose productions they can at best only obtain at second-hand.

What emerges is, again, the transcendent importance of nutrition in evolution. We can explain the rise of form as largely determined and even pre-determined by nutrition. We

can do it without having recourse to teleological explanation or to "design" of a "prescient-from-all-eternity" order (to use a term of Samuel Butler's).

We may also incidentally admire the keen insight of that great genius, Robert Chambers, the long unknown author of the *Vestiges of Creation* (1844-53), who taught the principle of "progressive development" years before Darwin, and pointed to "the force of certain external conditions operating upon the parturient system" as an important factor of evolution.

Experimental Morphology shows that on a small scale the same, or similar, influence can clearly be seen to be operative. Thus Goebel, Vöchting, Knight, Klebs, etc., have shown that if the primordia of a shoot are exposed to altered conditions of nutrition at a sufficiently early stage, a complete substitution of one organ for another is effected. The paramount influence of nutrition in pre-determining form is thus again manifested.

As regards the "summary exploitation" of the coloured cells in *Convoluta*, we must remember that the plants here concerned are primitive and short-lived. From the standpoint of the species, as Prof. Keeble tells us, "the relation of certain of its individuals with *C. roscoffensis* or *C. paradoxa* is an episode without significance. . . . Of a swarm of flagellated green cells, some small percentage meet the picturesque fate of forming a tissue in the body of an animal. The others pursue a less romantic adventure, either as green, self-supporting organisms or as colourless cells which batten on the offal of the sea."

By facilitating abstemiousness and sexual reproduction in the *Convoluta*, the algal cells sacrificed are instrumental in preventing the animal from lapsing into redundant and degenerate forms of reproduction and becoming a pest similar to the rose-aphis. They may thus be viewed as sacrificed vicariously in order to prevent worse destructions, worse calamities.

It is a fact that *C. roscoffensis*, which is more moderate and more symbiotic in its behaviour than *C. paradoxa*, is pre-eminently gregarious and, by comparison, a slow breeder.

C. paradoxa, which is less regular in its habits, less reliant upon symbiosis than *C. roscoffensis*, and likewise less abstemious, is solitary. Its large and surfeited eggs hatch with extraordinary rapidity.

During the very important period of maturing its eggs, *C. roscoffensis*, as Prof. Keeble has shown, remains above all temptation to devour anything, though the choicest bits may be offered it. This is not the case with *C. paradoxa*, with its gluttonous and surfeiting habits. It is a glutton throughout its life, as Prof. Keeble has told us. Here, the bad habits have become overpowering and—such is the nemesis of bad specific habits—a corresponding surfeit of embryonic nutrition has to be provided. I have dwelt on the importance of this explanation of “reproductive nemesis” in previous volumes.

The example of *C. roscoffensis* shows that the true need of an animal is plant-food—in due season and obtained under conditions of symbiosis. The higher the degree of symbiosis the higher the adequacy of the food and the resulting possibilities for achieving rise of type.

We are told by Prof. Keeble that green and yellow or brown cells resembling in a general way those contained in the bodies of *C. roscoffensis* and *C. paradoxa* are found in many different kinds of animals belonging to the lower groups, and further that, although sometimes there may be indications of a former free living existence of the green cells, the case by no means always stands so clearly.

Indeed, the problems presented by the chlorophyllous cells of animals are too numerous and important to be dismissed by means of a loosely-drawn inference of this sort. To the possession of chlorophyll the plant owes its powers of photosynthetic manufacture; and to the absence of this pigment from the cells of animals is due the dependence of the animal world on the world of plants for food supplies. Yet, low down in the animal kingdom, organisms exist which, though undoubtedly possessed of distinct animal characteristics, contain chlorophyll and use

it for the manufacture of carbohydrate food. Thus, species of *Euglena* (e.g., *E. viridis*), which stand near the parting of the ways which lead, the one to the animal kingdom, the other to the vegetable kingdom, contain chlorophyll, and use it for photosynthetic purposes. Now *Euglena viridis* is undoubtedly an animal. The single cell or protoplasm of which it consists is provided with a gullet, into which solid particles may pass and thus be ingested by the animal. The membrane which encloses the organism is not composed of cellulose (the cell-wall substance of typically vegetable organisms) and in yet other ways *Euglena* gives evidence of its "animal" nature.

Although zoologists and botanists are agreed that the genus *Euglena* belongs to the animal kingdom, yet it possesses the power of constructing a green pigment—chlorophyll—which is identical in physical properties with that which occurs in the chloroplasts of plants. Here there is no question, apparently, of any swallowing by *Euglena* of plant cells. The animal cell makes the pigment in the same way as a plant cell makes it, and, having made it, uses it for photosynthetic purposes.

Euglena viridis thus seems to present a more reliable and, probably, a more ancestral degree of plant-animalism than *Convoluta*. It is more emphatically than *Convoluta* indicative of the true ancestral symbiosis from which we may conceive the subsequent bio-economic symbiosis between plant and animal to be descended. Similar to the evolution of sex with its primitive hermaphroditic form, we see how from a comparatively localised area by means of continuous symbiogenesis with increasing efficiency, a greater differentiation with consequent greater progress could be achieved. All that was subsequently necessary to the further step of biological symbiosis was that the partners should have evolved a sufficiency of individuality, of mutuality, and of mutual forbearance, to remain tolerably complementary though with less confinement, less attachment, and less limitation.

Again, just as in hermaphroditism perpetual in-breeding is "abhorred" by Nature (see Darwin's classical experiments), so, we may take it, that by the same provident and wise Nature, in consequence of her bio-economic necessities, a state of (predaceous) "in-feeding," such as the summary exploitation of the green cells of *Convoluta*, is "abhorred." It is relations leading to abiding gains, abiding values, that are required

instead. *Euglena* neither appropriates nor swallows its plant cells. It has, on the contrary, struck up a genuine domestic symbiosis between plant and animal cells. Such a genuine arrangement contains the promise of a fruitful symbiogenesis and subsequent fruitful stages of biological symbiosis.

If in course of evolution the vicarious plants have evolved secrets of manufactures not possessed by the animals, the latter need not be the poorer for this reciprocal differentiation, so long as they remain tolerably symbiotic in their behaviour. Just as the actual position of a plant in the scale of evolution is in accordance with its bio-economic productiveness, so, broadly speaking, the actual position of an animal is in accordance with its relations to the plant kingdom. As a general principle, one may lay it down that cultivators (“*arare*”—Aryans among humans) must always in the long run rise superior to depredators (hunters).

The cultivator (except in “*Raub-bau*”) takes for his pains no more than is compatible with the powers of the cultivated species; nor are they the poorer for being stripped of their surplusage. Plants, like bees, seem to resent (if the term be permissible) only extreme degrees of depredation in their cultivators. (Prof. Eimer reports that: “According to statements which seem to me perfectly reliable, bee-keepers who allowed their bees no peace and continually took from them the last drop of their honey, have sometimes been suddenly attacked by them, apparently with a common purpose, and been very severely injured by them.”)

The powers of production on the part of the photosynthetic plant are enormous, and the plant is also in this respect a marvel of efficiency.

“In the formation of carbohydrates, for example,” says Prof. A. B. Macallum, “the chlorophyll-holding cell makes use of processes of the most speedy and effective character. Nature works unerringly, unfalteringly, with an amazing economy of material and energy.”

We may reasonably assume that it was due to the increasing photosynthetic efficiency and general productiveness of the plant that changes of form and of character with subsequent progressive development generally became possible in the organic world.

As regards the primitive *Euglena viridis*, we can see from Prof. Keeble's remarks how the character of an organism fluctuates with fluctuations in its modes of nutrition.

In certain circumstances chlorophyll disappears from the body, and *Euglena viridis* passes into a colourless phase. When in this state the animal, if it is to feed at all, must do so by ingesting ready-made food. That is, from being a holophytic organism—one with a typically plant-like mode of nutrition—it becomes heterotrophic, that is, it feeds on ready-made organic materials, obtained from its environment. After a time it may reconstruct its chlorophyll and become free once more to manufacture by photosynthesis its organic food-substances from the raw, inorganic materials of its environment.

Here we have only an alternation of holophytic and heterotrophic habits and of the respective characters. The power of photosynthesis is not, however, permanently lost. The organism is even capable of a double state of what I have termed cross-feeding. In course of progressive plant-animal development the differentiating animal parts had to justify their existence by becoming useful adjuncts to, rather than devourers of, the strenuous green cells; nor could they indulge in reckless and indiscriminate "heterotrophism."

As regards the alternations of feeding habits and of form, Prof. Keeble puts the question:—

If one species of animal can do this, why should not another even more highly developed species possess like powers? Why should there not appear, here and there, animals which resume the habit possessed by their ancestors, construct chlorophyll and become independent, photosynthesising organisms?

The answer is that this would constitute a retrogression from the bio-economic point of view, and that the bio-economic factors now established in the world are too powerful to permit of such retrogression. Moreover, animals are debarred from

such a reversion by the very fact of their protracted specialisation as independent plant complements. Specialisation must entail limitations of some kind. Evolution has proceeded by biological symbiosis superposed on domestic or primitive symbiosis. Primitive symbiosis proved useful wherever biological symbiosis for one reason or another was impracticable, as in the early ages, and possibly for purposes of pioneer work after glacial periods, as it does now in the case of the arctic lichens.

Prof. Keeble himself suggests that the circumstances making for the adoption of a communal mode of life in the remote past were much the same as in the case of many lichens in the present day, and that whilst the colourless tissues specialised increasingly as purveyors of supplies to the chloroplasts, the latter specialised increasingly as experts in photosynthesis. This I believe to be true of all normal instances of primitive symbiosis. If this explanation does not meet the case of the *Convoluta*, as Prof. Keeble evidently thinks, we must remember that we have here essentially a retrogression, a degeneration, and that, too, in the most important, the bio-economic, sense. The case of the lichen stands quite differently in so far as it represents a proper and permanent—not a one-sided—working arrangement. The partners remain active and co-operative to a great extent, and the result is that the total domestic and bio-economic output of work is increased.

In the case of the *Convoluta*, the plant cells by relaxing their normal activity and depending partly on ready-made and surfeiting nitrogenous (waste) material coming from the animal tend to lose their vital photosynthetic power, a loss too great to be made up by their gains in other directions. The animal partner, on the other hand, remains only just sufficiently active to obtain the barest amount of "love-food" indispensable to its sexual reproduction, *i.e.*, the "infection" by the algal cell means scarcely more than a safeguard against complete loss of sexual reproduction, a preventive against

complete parasitism, for which temporary advantages the animal surrenders its birthright of genuine symbiosis and its chances of future symbiogenesis. Convolutal association is thus a makeshift arrangement, retrogressively come to. It is not on the lines of progressive reciprocal differentiation, and the limitations incurred are not balanced by a commensurate physiological or bio-economic advantage as in the case of the lichen, to which we shall have to refer again later on.

Prof. Keeble's evidence confirms the view that the green cells in *Convoluta* are degenerates. They show nuclear degeneration. The great majority of them occurring in the adult animal are not complete cells, but cells which show all stages of diminishing nuclear substance. "Those green cells whose nuclei are least degenerate are capable of division, but even they have suffered. They are no longer able to form a cell-wall nor to exist as independent organisms."

The algal cells in these associations, therefore, are not on the road to progressive reciprocal differentiation, but, on the contrary, "on that which leads to complete loss of independence." Hence they lose their progressive bio-economic value, and as the advent of the enucleate stage in the green cells may be "the signal to the animal to devour them," so it may well have been the lack of progressive inclination associated with a desire for surfeit which originally singled out certain cells for a career of failure—for a merry though a short life. The idea that the essential degeneration of the green cells as here depicted may be the signal to the animal to devour them, and thus end a short period of inadequate symbiosis, according to my interpretation, is of great significance, for I believe it adumbrates the fact that cessation of due symbiotic labour marks the starting point of the phenomena of disease and of extinction in the biological world.

This I have recognised for some time, and it is a recognition I am convinced of some considerable importance. To be able to diagnose the earliest phases of (biological) disease is no small matter. To be able to say where physiology ceases and

pathology begins, marks a progress which will be most appreciated by those who know well how inadequate and haphazard classifications have often hitherto been. As a reviewer E.F.B. (Dr. E. F. Bashford), in *Nature*, 7/5/14 (anent a work by Dr. C. P. White on *The Pathology of Growth: Tumours*), states:—

“Pathology is still so often restricted to or actually confounded with mere morbid anatomy”; and the same writer goes on to say that a “wider recognition of disturbance of function,” a “more wide-visioned outlook on the processes of disease,” are required.

To return, however. “We conclude, therefore,” says Prof. Keeble, “that the alga which is the infecting organism of *C. roscoffensis*, lives a double life.” . . . “As a green cell it is holophytic, that is, it manufactures photosynthetically its food materials. As a colourless cell it is a saprophyte, feeding like an animal on ready-made organic material.” All this I have now interpreted to mean that the alga, tired of the physiological labour involved in “cross-feeding,” chooses the easier and more indulgent mode of “in-feeding” by seeking ready-made organic material. The “infected” animal in turn is similarly inclined to be drawn into short-lived “liaisons” (expedient, but not truly symbiogenetic in value). “Swallowing eagerly all the minute particles that come its way, *C. roscoffensis* cannot escape its destiny,” i.e., of becoming “infected.”

To put it now more explicitly: *C. roscoffensis* becomes “infected” by certain green cells as the result of morbid inclinations on either side. Gluttony makes strange bed-fellows! Birds of a feather flock together!

Prof. Keeble dwells on the pathetic dependence of *C. roscoffensis* on the “infecting” organism—so great a dependence as to justify, as he thinks, the title of plant-animal! But what he overlooks is that the title would be more appropriate were the dependence less absolute and duly complemented by reciprocity. The

real lesson is that even a degenerate green alga of the group of the primitive *Chlamydomonadineæ* can become a plant complement of the animal *C. roscoffensis*, a relation which, though lacking in permanence, yet at least provides the indispensable pabulum for sexual reproduction. This shows how ill-advised animals are in general to divorce themselves through bad food habits from direct reciprocity with the vegetable world.

The ancestors of both alga and animal at one time no doubt were strictly cross-feeding in their habits.

Just as holophytic (cross-feeding) plants require different food materials from the soil, so the animals—first arisen as particular plant-partners, *i.e.*, from a plant soil—require a particular plant-food for their normal purposes of life.

As evolution progressed, however, the dependence ceased to be as particulate as it was in the beginning, and plants and animals became enabled to strike up most varied inter-relations—although perpetual in-feeding, for vital bio-economic reasons, was always abhorred by nature.

The success of the divorce of an animal species from direct reciprocity with the plant is only apparent, for it is purchased at the expense of physiological capital and of survival-value. Nor can it be denied that ultimately the dependence of “in-feeders” on plant-life is nevertheless very real. In the case under review, *C. paradoxa* more markedly than *C. roscoffensis* presents the pronounced transition from a cross-feeding to a conspicuously “in-feeding” (and surfeiting) habit. To say that its dependence on a particular plant-food is less absolute than that of *C. roscoffensis* is not saying much in its favour, biologically considered. This kind of independence (from biological symbiosis) is in all cases too dearly purchased, *i.e.*, it is only gained at the expense of those values which constitute more particularly the physiological capital of a species. “Freedom with Virtue takes her seat.” *C. paradoxa* also bears out strikingly the truth that an “in-feeding” type

lacks the proper symbiotically obtained bio-chemical food-stimulation, and is consequently in a permanent condition of craving or hunger. It loses the sense of proportion, and is driven frequently to make up by quantity what is lacking in quality. Thus it becomes ravenous and gluttonous. As we have already noted, Prof. Keeble states that marine animals are always hungry; but no doubt this applies to all animals that are perpetual "in-feeders."

The mole, a typical "in-feeding" terrestrial quadruped, is an excessively voracious animal. It can endure no long interval between meals, hunger soon ending in death. When pressed by hunger, it will attack and devour even one of its own kind, and its practice is immediately to tear open the body of any bird or quadruped which it has killed, and, inserting its head, to satiate itself with the blood. Such instances can easily be multiplied. That we are dealing in such a case with extreme morbidity, with an extreme parasitic diathesis, seems hitherto not to have struck any naturalist. In their opinion such instances represent normal life—wild animals being represented as having no diseases! To look upon it differently would be courting the very inconvenient necessity for elucidating "the slippery basis of metabolism"! (It is certainly courting "scientific" intolerance.) I have expressed my conclusion on these matters thus: "Nature abhors perpetual in-feeding," and the recognition of this most important evolutionary law can no longer be shirked. There is startling and overwhelming evidence in its favour on every side. Some may be gleaned, for instance, from recent discoveries anent the biological transmission of disease.

The transmission of Plague by fleas, as reported in *Nature* (19/3/14), provides an instance of the increasing morbidity of the "in-feeding" habit once it has assumed the proportions of a permanent parasitic diathesis, and of its danger to the biological community in general. These most laborious and well-set-out researches we owe to Mr. A. W. Bacot and Prof. C. J. Martin. This is their conclusion:—

Under conditions precluding the possibility of infection by dejecta, it was found that two species of rat fleas, *Xenopsylla cheopis* and *Ceratophyllus fasciatus*, fed upon septicæmic blood, can transmit plague during the act of sucking, and that certain individuals suffering from a temporary obstruction at the entrance to the stomach were responsible for most of the infections obtained, and probably for all. In a proportion of infected fleas the development of the bacilli was found to take place to such an extent as to occlude the alimentary canal at the entrance to the stomach. The culture of pest appears to start in the intercellular recesses of the proventriculus, and grows so abundantly as to choke this organ and extend into the œsophagus. Fleas in this condition are not prevented from sucking blood as the pump is in the pharynx, but they only succeed in distending an already contaminated œsophagus, and, on the cessation of the pumping act, some of the blood is forced back into the wound. Such fleas are persistent in their endeavours to feed, and this renders them particularly dangerous.

The point of particular interest here is that the more intense the morbidity of the flea, the more "persistent it gets in its endeavours to feed," which renders it "particularly dangerous." If we have here apparently only a special case, if it be pleaded that it is only accidental that in this instance the alimentary canal becomes occluded at the entrance to the stomach, causing extreme thirst of the flea, our reply must be that all "in-feeders" eventually find themselves in a similar plight and confronted by similar precarious circumstances. All "in-feeders" are, and are bound to become increasingly fastidious. The fastidiousness of the flea is such that it requires warm blood for its sustenance. "He only sucks the tasteful blood." How is it to acquire the modicum of biochemical substances which its parasitic habits have precluded it from obtaining direct from their true (symbiotic) source, except by having increasing recourse to dishonest means, *i.e.*, by preying on warm-blooded mammals?

If the flea—again typical of all "in-feeders"—provides no positive share of biological symbiosis, it provides, *per contra*, the temptation and the soil for invasion by pathogenic micro-organisms. When the fleas suck infected blood into their stomach, the plague germs multiply enormously within them.

"A flea once infected has very little prospect of future happiness." This is well put, although the substance of it and its wide bearing as a general biological and sociological principle was already known to Dean Swift:—

Great fleas have little fleas, and lesser fleas to bite 'em,
And these fleas have other fleas, and so *ad infinitum*.

That the rat flea thus becomes an intermediary of disease only again shows that anti-symbiotic instincts in course of time must set up a vicious circle—the rat in turn being a most voracious and most unclean "in-feeder." "Shall they not rise up suddenly that shall bite thee, and awake that shall vex thee, and thou shalt be for booties unto them"?

An "in-feeder" may be said to rely upon inferior (second or third hand) physiological currency, and this means, as I have shown in previous volumes, that by an operation analogous to that of Gresham's law of currency, the superior physiological currency is gradually driven out from the physiological economy of the species. The result is physiological bankruptcy with concomitant loss of good character and ensuing criminality—judgment turned into gall, and the fruit of righteousness into wormwood.

The importance of good physiological currency and associated habits, however, is only very partially realised by our investigators. Prof. Keeble very tentatively suggests that in *C. roscoffensis* the algæ may produce and supply a hormone "entrusted *by custom* (*italics mine*) with the task of signalling to the animal to proceed with the business of ordered development." Thus, at any rate, we get the idea that what measure of "ordered development" there is in an animal, depends on "customary" supplies of "signalling substances" by the symbiotically related plant. But is this all? Is it only due to the quite recent discovery of such minute and as yet very little known substances as "hormones" that we can know anything about the true relations between plant and animal—a matter upon which our whole existence depends?

What are the various full and normal "customs" obtaining between those physiological complements?

Did we not find, for instance, that the very material for the eggs of *Convoluta* is provided by the green cells? Have we not now learned that the whole "business" of the animal is inseparably bound up with that of the plant, and vice versa?

What the animal wants is good currency—direct from the physiological mint, *i.e.*, the plant, and won by appropriate biological symbiosis, and as regards customs it is desirable to adopt the Pythagorean maxim: "Fix upon that course of life which is best and habit will make it the most delightful." *Convoluta* has not fixed upon the best course of life but has retrogressed from it. The divorce from biological symbiosis, however, is not yet complete, and some former "custom" still survives. "Custom" *per se*, of course, is inadequate as an explanation; for "custom" may have deteriorated. Bad customs must prevent rather than promote ordered development. The effect of beneficial ancient *Convolutal* "custom" is shown in the phase of comparative "abstemiousness," the effect of evil recent custom in the phase of voraciousness, particularly by *C. paradoxa*. Customs are no more fixed than species, and, indeed, the change of species is primarily, I assert, due to a change of "customs"—the most prominent in importance being the feeding "customs." Hormones, like enzymes, vitamins and alkaloid poisons, only follow in the wake of bio-economic "customs." They determine developments precisely in so far as the efficacy deputed to them has in the past been evolved by (good or bad) bio-economic "customs."

The latter-day "intimacy" of *Convoluta* and algæ has its antecedents in primordial relations of a different order. "The association between green cells and animals does not begin with the entrance of the green cell or its colourless antecedent into the body." The acquaintance began with an identity of phototropic response. Since we have already seen that frequently tropistic response is ultimately connected with

nutrition, we may assume that there existed thus in early times a bio-economic (symbiotic) bond between cells and animals based—in the last analysis—upon genuine biological symbiosis; much in the same way as we saw that there exists a certain correlation between the nutritional activities of many *Copepods* and those of neighbouring green algæ. It is thus again evident that normal and vital bio-economic relations between plant and animal can and do quite well exist without intimate attachment. Intimacy of attachment is no more the criterion of the normality of relations than it is the criterion of abnormal, *i.e.*, parasitic relations, although in rank parasitism attachments abound.

The fact that the free-living alga frequently settles down indolently in the mucilage which forms a slimy coating over the body of *C. roscoffensis* constitutes, in my opinion, an intimacy of the retrogressive order. The same interpretation must be given to the fact that the egg-capsules apparently exert a definite chemical attraction on the motile green cells.

If here we have a case where “aus dem Keim der Bekanntschaft nach und nach holde Gewohnheit entspross,” this is rather in the direction of the parasitic relation. We must remember that chemical attraction, like eating, “is a mode of love,” and that likewise, as has already been pointed out, there is a vast domain of morbid attraction and of morbid hunger.

Well may it be that it is the egg-capsules themselves that provide some of the green cells with an alluring medium for growth without exertion. Some of the eggs which have died eventually provide a still stronger temptation, a still richer soil for indulgence and luxuriousness on the part of the alga. We may assume that under the original symbiotic arrangement both plant and animal thrive well, and that both had enough and plenty to spare. Instead of using their surplus, however, to mutually progressive (symbiogenetic) purposes, temptation led them into the path of indulgence.

Such is the frailty of life that the advent of better circumstances or of advantages due to ancestral efforts is frequently made use of in a retrogressive manner, and is followed by a relaxation of effort and an inclination to proceed along the road of least resistance and of selfish expediency, until finally the organism may cease altogether to contribute "à l'entretien de la vie générale."

The animal first rendered strong by auspicious ancestral dynamics proceeds to abuse its powers, and destroys and devours the weaker instead of cultivating and protecting its true complement. When *in extremis* of hunger and of bankruptcy, it does not hesitate even to devour its own kith and kin. The diathesis so produced in turn provides the soil for other would-be profligates of every description. At the same time the temptation is provided for certain plants to take the step from cross-feeding (holophytism) to in-feeding (saprophytism), which is certain to lead in turn to great changes in both plant and animal kingdoms. In the case of the *Convoluta* partners some of the algal cells became colourless and in that form acquired the habit of obtaining food material after the manner of an animal, *i.e.*, they were on the road to lose their characteristic photosynthetic capacity without any commensurate permanent gain—except perhaps indirectly in their usefulness as scavengers.

Whereas cultures of truly symbiotic plants are generally seen to thrive best in mineral solutions, the case of *Convoluta* presents the eloquent fact that:—

"Comparative cultures of the free stage of the infecting organism have demonstrated that the alga flourishes better when supplied with nitrogen in the form of uric acid than when it is supplied with a nitrate (potassium nitrate)."

The "infecting" algæ, therefore, under the stimulation provided by a retrogressive partner are definitely on the road to the saprophytic character, the saprophytic diathesis. An inferior physiological currency is ousting a former nobler currency—associated with strenuous character and photo-

synthetic labour—until eventually after a short period of inflation a corresponding degree of physiological and economic sterility is reached. Finally, in other cases of similar decline the further stage of utter physiological bankruptcy illustrated by obligatory parasitism ensues in due course.

The changes produced in the animal by this undue "intimacy," this retrograde symbiosis, are no less startling than those produced on the algæ, for it has lost its excretory system, which, surely, is not a progressive atrophy, but pure degeneration. "Unlike their allies, such animals possess no apparatus for the systematic discharge of the waste products of their metabolism."

What becomes of the waste products—"compounds of nitrogen of a kind useless to the animal"? They are stored in the tissues of the body, and Prof. Keeble informs us that, though they are useless for the nutrition of the animal, they serve well for plants. This last remark, however, should be qualified by the addendum that though such substances *may* serve for the nutrition of plants, yet they do so more or less retrogressively. In *Survival and Reproduction* I have pointed out that an excess of nitrogen produces injurious effects upon plants, and that the notion so widely held that the effectiveness of manure is proportionate to its unsavouriness is based on fallacies. Plants, on the contrary, suffer in viability from such manure which induces a "dyspeptic" condition of the soil.

The green and yellow-brown cells, then, in the bodies of the *Convoluta*—spoken of in this connection by Prof. Keeble as the "hosts"—obtain access to and utilise the stores of waste nitrogen-compounds accumulated therein.

The plants flourish in the bodies of these animals because there they discover large accumulations of waste nitrogen compounds; the animals, looking to the algæ to come and take charge of the work of getting rid of these waste substances, have ceased to construct any excretory apparatus whatever. Hence it is not surprising that, when the algæ fail to appear in their bodies, the animals suffer. It may be that the death of uninfected animals is not merely the consequence

of starvation, but is at all events hastened by poisoning due to the accumulation in the tissues of the products of nitrogenous metabolism. According to this view, uninfected *C. roscoffensis* dies as the consequence of an aggravated attack of "uric acid trouble."

And thus Prof. Keeble is almost driven by the logic of his results to conclude that at bottom we are here dealing with a parasitic diathesis, which, as it is the fundamental cause of retrogression in both partners, may be somewhat relieved by virtue of that rudimentary symbiosis still inherent in the arrangement; but becomes acute and aggravated if this modicum of symbiosis is not reached.

True, Prof. Keeble guards himself immediately by qualifying his suggestion as "somewhat fantastic"; but as he brings forward further evidence in support of that suggestion, we can see that it is only the novelty of the diathesis-view which causes this perplexity.

Although the evidence provided in favour of this hypothesis may be somewhat slender in the case of *C. roscoffensis*, it is decidedly more plentiful in the case of *C. paradoxa*. "A far more greedy feeder than the green species, its accumulations of nitrogenous waste substances are much larger than those of its ally."

Prof. Keeble apparently does not realise that the luxuriant growth of cells which here results from such a soil, in reality amounts to an inflation which is sure to be followed by exhaustion and by precarious biological concomitants. He wavers between a "symbiotic" or a "parasitic" explanation, with an inclination towards the latter, as is apparent from the following:—

In such Capuan circumstances, the algal cells grow and divide luxuriantly. Their photosynthetic activities increase, for only in the presence of plentiful supplies of nitrogen does the chlorophyll-apparatus work well. Large quantities of carbohydrate material are produced in the algal cells—enough for the needs of these cells and for those of the animal. All goes well, so well indeed that *C. roscoffensis*, less conservative than its ally, contents itself entirely with the supplies of food-material, of fat, and also of organic nitrogen compounds, provided by its green cells and abandons the practice of fending for itself.

The ample tribute which it receives suffices for its needs and also for the provision of its eggs. But the weakness of the system here discloses itself. This handing of nitrogen-containing substances to and fro from animal to plant and from plant again to animal cannot go on indefinitely or without loss. Sooner or later, the animal finds itself lacking in essential, nitrogen-containing food-materials. Supply fails to equal the demand. Then the animal is under the dire necessity of digesting its algal cells. To satisfy an imperious present need, the plant-animal destroys the source of its supplies.

Thus the animal repudiates the association and, having digested its green cells, *C. roscoffensis* dies of the very complaint—nitrogen-hunger—which the green cells sought to avoid by their intrusion into the body of the animal. To dismiss the association between animal- and plant-constituent of the plant-animals by labelling it symbiosis is to miss the varying significance of the association. Looking at the relationship from the standpoint of the animal, it is one of obligate parasitism. Apart from their algal cells, *C. roscoffensis* and *C. paradoxa* are unable to live. The existence of either species depends upon the infection of the individuals of each successive generation. Where the infecting organism is absent, there *C. roscoffensis* does not exist. Hence its restricted range. From the standpoint of the species “infecting organism,” the relation of certain of its individuals with *C. roscoffensis* or *C. paradoxa* is an episode without significance. Unlike the animal, which bears the inherited impress of the relation in its lack of an excretory system and in the habit of patient waiting—abiding the question of infecting—the alga is free. Of a swarm of flagellated green cells, some small percentage meet the picturesque fate of forming a tissue in the body of an animal. The others pursue a less romantic adventure, either as green, self-supporting organisms or as colourless cells which batten on the offal of the sea.

If all's well that ends well, we have thus good reason to think that all was not well from the very beginning in the relations between plant and animal as represented by the *Convolutal* arrangement.

By hinting at “obligate parasitism,” Prof. Keeble implies that some deeper cause than a mere normal nitrogen requirement is here involved. We can have no “obligate parasitism” without a parasitic diathesis, *i.e.*, an abnormal nitrogen hunger. This abnormal craving is bound to increase, and can be satisfied the less, the greater the divorce from genuinely symbiotic relations becomes. That the same morbidity in some

cases produces very obvious and conspicuous self-destructive propensities in a species is well borne out by the case of certain carnivora, which, in the depravity of their appetites, devour their own young, or, in captivity, turn upon their own bodies and do themselves serious or even fatal harm. *In se semper armatus Furor*. It may also be added in this connection that like the carnivora, the *Convoluta* are characteristically evil-smelling "beasts."

When Prof. Keeble says that a number of the independent *Chlamydomonadineæ* in the ordinary way are inclined to become saprophytes—"colourless cells which batten on the offal of the sea"—this again illustrates the parallelism with carnivora which latter are battenning on the offal of terrestrial life, with identical negative biological results.

Even the facts of Chemotactism bear out the same parallel. Those of the flagellated algal cells which were hankering after the nitrogen preserves—the uric acid—of the animal and presently are to share the fate of all sustained profligates, namely, degeneration and untimely death, are attracted to the egg-capsules of the evil-smelling animal by chemotactic influences. All profligate organisms are thus liable to attractions by pathological emanations, and degenerates of most varying types are thus gathered together by their morbid inclinations—a veritable diabolic "selection," as I have termed it in my *Nutrition and Evolution*. "I have left you free to choose between life and death and good and evil." It was reported in the *Times* (17/11/13) as a statement by Sir Emerson Tennant that the savageness and man-eating propensities of leopards are such as to render them "peculiarly attracted, presumably by scent, to patients suffering from small-pox, so that the medical officers in charge of small-pox hospitals in leopard-haunted countries have to take especial precautions to keep the animals away."

In a similar way it is held by some botanists that if a parasitic hyphæ pierces some plants or their stomata and refuses to enter others, this is because in the former case there

are chemotropically attractive substances present which are absent from the latter—*i.e.*, the morbidity of the “soil” attracts pathogenic and would-be pathogenic organisms.

Thus we see that in-feeding organisms have failed to fix upon that course of life which is best in the long run. They are, instead, led away by their bad habits from the good physiological currency, from those (to us) pleasant-tasting and smelling substances in nature which are usually wholesome and rich in adequate bio-chemical potency. They are debarred by their morbid habits from first-hand supplies of vitamins and the virtues of that indispensable medicine of nature supplied by vegetable juices and their ingredients, and consequently they develop increasing metabolic abnormalities. An old medical maxim runs: “*Pathologia physiologiam illustrat*,” and, indeed, the above instances of “chemotactism” are pregnant object-lessons in pathology. They show how incipient pathology, as I would on symbiotic tests distinguish it from normal physiology, indeed constitutes a most important chapter of the evolution theory. The point to be insisted upon is this, that no mode of nutrition can be considered normal unless it is associated with an appropriate degree of symbiosis.

Prof. Keeble puts forward the theory that “the great saprophytic groups of the fungi and the bacteria owe their origin to the changed mode of nutrition imposed upon them by lack of nitrogen.” Whatever be the direct or indirect reasons for a change from holophytism to saprophytism, the universal fact remains—and that is why I must dissent on general grounds from Prof. Keeble’s explanation of a “nitrogen scarcity” existing in nature—that a change from an erstwhile cross-feeding to an in-feeding mode results in pathological developments. “*Multo plures satietas quam fames perdidit viros.*” What nitrogen scarcity exists must be put down to the prevalence of morbid feeding habits. That, at any rate, such a change involves a deterioration, a loss of

status, is well emphasised by Prof. Keeble's own remarks on this subject:—

That the fungi are examples of descent by reduction is undisputed. All the evidence points to their derivation from chlorophyll-containing algal ancestors. Having lost their chlorophyll, and, with it, their powers of photosynthesis, they are now condemned to obtain both carbon and nitrogen in the form of organic compounds and hence are compelled, with the bacteria, to play the part of Nature's scavengers. In their quest for food, they settle either on the dead remains of plants or animals, or, invading the living organism, they exchange a saprophytic for a parasitic mode of life.

The eminent botanist just misses, I believe, the essential pathological and associated bio-economic implications. It need not follow from my view of these matters that we must deny all usefulness to saprophytism, carnivorism, or even to parasitism. They have their use just as disease and death have theirs. They are "ein Teil von jener Kraft die stets das Böse will und doch das Gute schafft." Evil in the end must subserve the good. So far from denying the presence of evil in wild nature—as the corollary to Darwin's Natural Selection theory inclines some to do—we find it to be widely prevalent: it is a bye-product of the evolutionary process which, however, is ultimately turned to use much in the same way as many bye-products are being turned to use in modern manufactures.

The degenerate organism, however, serves itself least. The world of strenuous plants can well afford to permit a few groups here and there to retrogress, much the same as the species *Chlamydomonadineæ*, as we saw, can afford to sacrifice a certain number of individuals for the purposes of pseudo-symbiosis.

For progressive purposes, however, it is only genuine symbiosis and all that it entails in character, in strenuousness, restraint and mutual forbearance that can guarantee a permanence of happy productiveness.

In *Evolution by Co-operation* I have demonstrated that parasitism is a failure because it violates what I conceive to be the fundamental law of co-operation in the biological world,

and concurrently I have shown work in the production of social values to be the central issue of the evolutionary process, and shown how untenable are those views which are based on a neglect of these two fundamental factors. From the detailed study of symbiosis it must now have become more apparent than before that unless the fact of the subordination of most other factors to the bio-economic factor is consistently taken into account, only very inadequate and partial or local views respecting the significance of biological phenomena are likely to prevail.

Having now, as I hope, seen sufficient reasons for a more discriminating judgment upon symbiosis and its rôle in the organic world generally, we are now in a position better to appreciate the case of the lichens in particular.

The symbiotic association between a (generally higher) fungus and a (generally unicellular, sometimes filamentous) alga forming together what is called a lichen, presents a striking illustration of the surpassing significance of co-operation and symbiogenesis generally. It has needed years of painstaking research and of controversy to establish the compound and dual nature of the lichen. The special fungi which take part in the association are, with rare exceptions, not found growing separately, whilst the algal forms are constantly found free. The reproductive organs of the lichen are of a typically fungal character. The algal cells are never known to form spores whilst forming part of the lichen-thallus, but they may do so when separated from it and growing free.

"The fungus," says the *Encyclopædia Britannica*, "thus clearly takes the upper part in the association."

The algal cells in this case are like the majority of the (vicarious) plantagens of a tree, which remain content with asexual reproduction in order the better to subserve the purposes of domestic and biological symbiosis, and they are satisfied to depute both the high privilege and the onerous duties of sexual reproduction to the more expert fungus.

Privilege and duties in nature are normally according to qualification and values, and we further see from this example that reproduction itself is normally subservient to bio-economic purposes. No matter how startling the mathematical possibilities of reproduction *per se* may be, no species obtains more scope than is warranted by its bio-economic usefulness. The first consideration of life is that the work of the world shall be done, and not that the mere reproduction of every species of organism shall continue without limit. Symbiogenesis rather than mere multiplication is the desideratum. So long as organisms continue strenuous, the material for reproduction and for variation is always provided, but reproduction may, if redundant, mean a mere waste of capital.

The problem of the lichen is how to produce ample capital for survival purposes which, as this case so beautifully illustrates, is inseparably connected with bio-economic purposes under external conditions which render the provision of capital by each singly or by the ordinary method of unattached biological symbiosis practically impossible. This calls for a sufficiency of sympathy of purpose, of metabolic and bio-economic compatibility and of restraint and mutual forbearance. Both partners must be willing to sacrifice some of the independence which is entailed by the more usual form of (unattached) biological symbiosis. The alga restrains its own reproductive tendencies—already moderate in view of the relatively great amount of vitality deputed to its photosynthetic activities—and this, not because of sterility or parasitic over-adaptation or parasitic atrophy, but in obedience to the principles of reciprocal differentiation—requiring mutual sacrifice and, in particular, sacrifice of the lower for the higher. The fungus, in view of its bio-chemical equipment, is the better qualified of the two for the communal labours of sex, and therefore the alga plays, as the *Encyclopædia Britannica* article says, a subordinate part, but it retains its own sexual faculties and remains capable of reproducing its kind when separated.

The alga is wisely conservative—its wisdom, as we shall presently see, bringing length of days in her hands—and, though adapting itself wonderfully to the changed condition of life, it yet retains what is essential, or might become essential, at any moment to its survival. Genuine adaptation thus always guards against parasitic atrophy of vital functions, though continually sacrificing the lower for the higher, and husbands those potentialities essential for continuous progress.

What is the usefulness, both domestic and biological, of this symbiotic co-ordination and subordination presented by the case of the lichen?

Lichens are able to live in situations where neither the alga nor fungus could exist alone. The alga is protected by the threads (hyphæ) of the fungus, and supplied with water and salts and, possibly, organic nitrogenous substances, and, in turn, it manufactures photosynthetically carbohydrates, the surplus of which it yields to the fungus.

This form of relationship (says the *Encyclopædia Britannica*) is now known in other groups of plants, but it was first discovered in the lichens.

Lichens are frequently found in the most exposed and arid situations. In the extreme polar regions these plants are practically the only vegetable forms of life and possess the capacity of resisting extremes of warmth, cold and drought without destruction. On a bare rocky surface a fungus would die for want of organic substances, and an alga from drought and want of mineral substances. The lichen, however, is able to grow as the alga supplies organic food material and the fungus has developed a *battery of acids* which enable it actually to dissolve the most resistant rocks. It is owing to the power of disintegrating by both mechanical and chemical means the rocks on which they are growing that lichens play such an important part in *soil production*. (Italics mine.)

And thus, again, we see the enormous and far-reaching use of symbiosis. We see how domestic and biological symbiosis are inter-connected and dovetail, as it were, into each other, just as do Bio-Economics and Bio-Chemistry. We see how many great biological functions are performed simultaneously and *pari passu* with the proper solution of

domestic problems apparently trivial by comparison, and this on the sociological side will be found to throw not a little light on the subject of the greatness of nations. We see that by proper symbiotic effort even the most humble organisms can produce a hereditary bio-chemical mechanism comparable in efficacy to the *corpus luteum* of the mammalia. It is not even necessary that they belong to the same species. Nay, what is more, we see that the true and complete hereditary mechanism rests normally everywhere upon a dual, *i.e.*, symbiogenetic basis.

These lowly types, moreover, in virtue of the adequacy of their symbiotic labours, become veritable pioneers of organic civilisation. In *Nature* (24/7/13, p. 541) we have a report of Dr. Otto Vernon Darbishire on Antarctic Lichens, and he tells us that:—

In Alpine and Arctic regions lichens do important pioneer work, helping to break up the hardest rock surfaces and prepare soil on which *other plants can grow*; while on steeply-inclined and bare rock, lichens, along with minute algæ, are in general the *first colonists*. (*Italics mine.*)

The lichens are characterised by their excessively slow growth and their great length of life. This slowness of growth is associated with great length of life and it is probable that individuals found growing on hard mountain rocks or on the trunks of aged trees are many hundreds of years old. It is possible that specimens of such long-lived species of *Lecidea geographica* actually outrival in longevity the oldest trees.

Truly “Ohne Hast and ohne Rast” seems to be the motto of the lichens. In the production of services and of biological values, in longevity and slowness of growth they compare favourably with many of the highest organisms. They present the symptoms of wholesomeness in many directions at the same time.

If evolution were merely a matter of achieving reproduction—as many biologists seem to believe—there would be little need for slow growth, nor for longevity and the expenditure entailed by the retardation of the period of reproduction. But if it is mainly *a matter of the maturation of biological values*, the *raison d'être* of slow growth with associated laboriousness at once becomes clear.

We are further told by the *Encyclopædia Britannica*:—

The resistance of lichens is extraordinary; they may be cooled to very low temperatures and heated to high temperatures without being killed. They may be dried so thoroughly that they can easily be heated to powder yet their vitality is not destroyed but only suspended: on being supplied with water they absorb it quickly by their general surface and renew their activity.

Their geographical range is more extended than that of any other class of plants, appearing as they do in the coldest and warmest regions—on the dreary shores of Arctic and Antarctic seas and in the torrid valleys of tropical climes, as well as on the greatest mountain elevations yet attained by man, on projecting rocks even far above the snow line.

The eminent power of meeting the most varying contingencies of life possessed by genuinely symbiotic organisms is thus again brought home to us, and it is an additional reason for rejecting the nitrogen theory tentatively put forward by Prof. Keeble. This power is identical with that which resists disease generally, and it justifies the view here expressed that symbiosis is the true antithesis to disease, just as, inversely, cessation of symbiosis is the beginning of all pathological developments. "He liveth long, who liveth well." True, the symbiotic association in the lichens is sometimes apt to degenerate into parasitism, the fungus killing the algal cells. Sometimes lichens will live parasitically on others. We must remember that in the lichen we have but a particular case of symbiosis, suited to particular conditions. The main line of evolution was by way of non-attached biological symbiosis. Generally speaking, however, the ubiquity and dominance of the lichen is clearly associated with its strenuousness.

Cora pavonia which in tropical regions is found growing on the bare earth is unique because the fungal element is also found growing and fruiting wholly devoid of algæ, whilst in the ascolichens the fungal portion seems to have become so specialised to its symbiotic mode of life that it is never found growing independent. (*Italics mine.*)

Again we see that there is no need in genuine symbiosis to surrender essential potentialities as in the case of parasitism. This instance also again points to the fact that originally there

existed a genuine bio-economic compatibility to render the association possible, that a previous integrity on the part of both partners smoothed the way for the union. We also learn that in the domestic arts many lichens have been highly esteemed as food and as medicine. They are of great importance as supplying food for man and beast, containing as they do starchy substances, and in some cases a small quantity of saccharine matter of the nature of mannite. In Lapland and other northerly countries they supply the winter food of the reindeer and other animals.

But the most singular esculent lichen of all is the "manna lichen" which, in times of drought and famine, has served as food for great numbers of men and cattle in arid steppes of various countries stretching from Algiers to Tartary. This is derived principally from *Lecanora esculenta*, which grows unattached on the ground in layers of 3-6in. thick over large tracts of country in the form of small irregular lumps of a greyish or white colour.

The emancipation of the children of Israel from Egyptian slavery necessitated at the same time emancipation from the flesh pots of Egypt if the race was to be rejuvenated. The rôle which manna—whatever its origin—played in this rejuvenation must have been immense. "And the children of Israel did eat manna forty years." It matters little for physiological purposes whether this manna was provided by a lichen or by some other strenuous vegetable organism. Like the eating of unleavened bread, it was a "change of diet," calculated to spell physiological emancipation from bad habits, and in its physiological significance it is comparable to the "change of diet" by *Convoluta* and rose-aphis when it flies off from cultivation into the fields. Nor was the lesson from the wilderness in vain. Throughout the succeeding centuries the Jewish people have provided martyrs not only for purely theological reasons but also in the cause of Mosaic dietary legislation. Huxley says:—

All that is best in the ethics of the modern world in so far as it has not grown out of Greek thought or Barbarian manhood, is the direct development of the ethics of old Israel. There is no code of legislation,

ancient or modern, at once so just and so merciful, so tender to the weak and poor, as the Jewish law; and, if the Gospels are to be trusted, Jesus of Nazareth himself declared that he taught nothing but that which lay, implicitly, or explicitly, in the religious and ethical system of his people.

The cardinal feature—implicitly and explicitly—of the Jewish law—as, indeed, even more pronouncedly so of that of the Buddha—is justice, including to a considerable extent justice to and sympathy with the lower creation, *i.e.*, the recognition of what I have termed bio-morality. Apparently the ancient law-givers held what Lancisi so pregnantly expressed in the seventeenth century: “*Quale est alimentum, talis est chylus, talis sanguis; qualis tandem sanguis, tales sunt spiritus.*” The children of Israel for physiological reasons alone seem likely to survive as the salt of the earth so long as they excel in loyalty to great cosmic principles. Only then will they be able proudly to boast: “Therefore will we not fear, though the earth be removed, and though the mountains be carried into the midst of the sea; though the waters roar and be troubled, though the mountains shake with the swelling thereof.”

CHAPTER II.

BIO-DYNAMICS.

It is an illusion that great men are the creatures of their times; they are born and bred in the undistinguished era that preceded.

The Elizabethans were born under Henry VIII., Edward VI. and Mary. The great Athenians of the fifth century before Athens tried to dominate Greece, and while she was growing men under the pacific rule of the Pisistratids, Imperial Athens exhausted the Athenian stock by two generations of warfare, and fell, never to rise again. The heroes of the French Revolution are all to be credited, biologically, to the *ancien régime*.—PROF. F. C. S. SCHILLER.

Tout dépend finalement du point de vue où l'on se place: et le point de vue final ne dépend pas de la science naturelle.—BOUGLÉ.

In the previous chapter my task has been to elucidate the essential quasi-economic principles which underlie symbiosis. It was found that this elucidation was calculated to supply us with important qualitative biological data and to facilitate biological orientation generally, and, in particular, to enable us to draw the line more rationally and more profoundly than has hitherto been possible between physiological and pathological developments.

If the diagnostic method so far deduced be reliable—and there is strong evidence in its favour—if it be also correct that we must seek for an explanation of what has happened by the study of what is happening, it follows that our diagnosis applies quite as pertinently to the dynamics of the past as to those of the present, and that it thus affords a valuable clue to the sifting of the positive from the negative factors of evolution and hence also to that most vexing of problems, that of biological “origins” generally.

One of the difficulties felt very acutely by biological investigators has been to distinguish between characters of

comparatively recent origin and those inherited from remote ancestors. The "remote ancestor" has constantly played the rôle of *deus ex machinâ* in the theory of evolution. For an account of the essential endowments of a species, or an order, or even of a whole class, we are generally referred back to a common progenitor without any explanation of how he may have come into being. Speaking of the advent of the mammary glands, reference to which was made in the previous chapter, Darwin tells us that they must have been developed at an extremely early period, "and we can know nothing positively about their manner of development." He also frequently refers to "our ignorance of the past history of each species."

My contention is that all species, strenuous and progressive, or indolent and degenerate, can be traced back to a strenuous remote ancestor, which arose symbiogenetically, *i.e.*, through protracted bio-economically useful association of (bio-economically and physiologically) useful units. The stored-up results of such symbiogenetic working associations are the *sine quâ non* of subsequent evolution, be it progressive or retrogressive.

In a degenerate we have frequently only rudiments left indicating a once truly useful purpose, and their origins and histories are usually overlaid by a plurality of perplexing adventitious "characters" correlated with anti-symbiotic and degenerate purposes, rendering it frequently extremely difficult to sift the grain of usefulness left from the chaff of uselessness superposed thereon. The usually very conspicuous adventitious "characters" associated and correlated as they are with morbid habits contracted at some time by an indulgent progeny are thus in the majority of cases apt to mislead us as regards the true character of the strenuous forbear.

We have seen how the *Convoluta* are conspicuous and remarkable among the Turbellarian worms in possessing no excretory system, and we have set this retrogression down to a parasitic diathesis. They are unlike their allies in this respect, and the evidence seems to point to the fact that their

ancestor was once possessed of an excretory system. The Nematode worms, which are mostly parasitic, and which, according to Prof. J. A. Thomson, "do not seem to lead on to anything else," are characterised by many startling features. "It is very interesting," says this leading biologist, "that the only animal types without wandering phagocytes are the Nematode worms (some of which, at least, have stationary phagocytes) and the Lancelets." (Absence of work with absence of symbiosis!) The parasitism of the Nematodes is frequently carried so far that in the resulting retrogression from the ancestral type no mouth or digestive system is represented. As soon as we come to the few free-living forms, we find that the ancestral features, such as a distinct mouth, a digestive canal and a vascular system of canals, can be recognised. Darwin noted in the *Origin of Species* that the hair-claspers of parasitic mites (*Acaridæ*) "could not have been inherited from a common progenitor." He says that "these organs must have been independently developed," but it did not apparently occur to him that this "independent" development was due to a vital departure from strenuous and symbiogenetic ancestral dynamics in favour of recent parasitic, and therefore anti-symbiotic dynamics. He did not perceive how vital a change from positive to negative dynamics is involved in every change from bio-economic strenuousness to sluggishness. Yet volumes could be written to demonstrate this truth by facts drawn from every class of organisms. Among the many conspicuous and puzzling features marking the change from ancestral symbiotic to later anti-symbiotic dynamics, I would mention excessive reproduction and excessive growth of reproductive and nutritive paraphernalia, excessive metamorphosis, excessive sexual dimorphism, excessive liability to hyper-parasitism, excessive development of parts of the nutritive apparatus—all these features more or less at the expense of high developments, *e.g.*, of brain. All these developments, I assert, must be classified as pathological, although hitherto this has been only partially recognised. That is to say the

physiological capital and energy accumulated by generations of physiologically upright and strenuous ancestors may easily be so abused by degenerate descendants as to lead to pathological conditions and even to monstrosities, and of this the organic world, I maintain, shews abundant illustrations.

In the case of bio-economically strenuous organisms the case is much simpler. They are not encumbered by adventitious growths of all kinds to such an extent as are degenerates, and therefore lend themselves more readily to our study of origins and of genealogical classification. All that is necessary in their case is to trace the successive steps by which organisation was perfected, *pari passu* with increasing symbiotic activities, bearing particularly in mind that fauna and associated flora evolved in mutuality; and, further, as Darwin has it, that after long intervals of time, the productions of the world are seen to have changed simultaneously, which, indeed, they must have done, being all involved in the web of life which tended by its own growing exigencies to raise the level of existence in the way I have depicted.

We have seen that habits, customs and behaviour—past and present—count for a great deal as momentum in biological development, and we have also seen that “good” conduct leads to symbiogenesis, and thus to higher-production as distinguished from mere *re*-production as a plurality of favourable nutritional, *i.e.*, bio-chemical and bio-economic circumstances are correlated with such conduct, and that, inversely, “bad” conduct leads to retrogression precisely through a loss of these correlated favourable factors. In accordance with these facts we have already drawn the distinction between positive and negative factors of evolution. It remains now to specify the qualitative distinction further and to define the “endowment” of a species due to and heritable in virtue of positive ancestral dynamics, *i.e.*, ancestral symbiotic strenuousness, as contrasted with the negative dynamics which may subsequently lead to continuous degradation. Everything that exists in the organic

world came into existence because of some use—the bio-economic use in particular being in the long run the chief determinant of survival. Organisms, moreover, live not only by virtue of, but also in spite of, what they are. In other words, there are both positive and negative confluents in the dynamic make-up of organisms and of species. Every organism thus has bequeathed to it a legacy of positive as well as negative ancestral dynamics, the former being connected with the original bio-economic use (and the resulting symbiogenesis), answerable for the evolution of the particular species, and the latter with subsequent anti-symbiotic developments and their correlations.

For brevity's sake, instead of speaking of original positive ancestral dynamics and subsequent negative ancestral dynamics, I propose to introduce the terms "symbiotics" and "anti-biotics" respectively for the particular kinds of influences with which I am here more especially concerned.

That there is a need for these terms is apparent in many ways. Prof. G. Klebs thinks that a special term is necessary to account for the fact that the systems of two allied species or varieties show a constant difference in their reaction to a similar environment. This he proceeds to do by saying that the "specific structure" is different in each case—as, indeed, it must be.

In the *original* (italics mine) cell, eventually also in every cell of the plant, the characters which afterwards become apparent, must exist somewhere; they are integral parts of the capacities or potentialities of specific structure. Thus not only the characters which are exhibited under ordinary conditions in nature, but also many others which become apparent only under special conditions, are to be included as such potentialities in cells; the conception of specific structure includes the *whole* of the *potentialities* of a species; specific structure comprises that which we must assume without being able to explain it.

Seeing that we are here concerned with "potentialities" and with the "inner world" of organisms, with functions and conditions of relatedness, it seems that a dynamic conception

is preferable to a "structural" conception—although, of course, Prof. Klebs would scarcely deny that there are dynamic influences underlying structure. Structure, indeed, follows in the wake of dynamics, *i.e.*, of conduct—which involves relatedness and dynamic action and reaction. That structure often arrives in a belated manner as a result of new behaviour—voluntary or involuntary—and, therefore, is not always the most reliable index of the true state of affairs, is otherwise fully recognised by Prof. Klebs. Thus speaking of some artificial interferences with the growth of plants, he states that the transformations of flowers thus induced become apparent about two months after the period when the particular cause began to act. "There is, therefore," he says, "*no close connection between the appearance of the modifications and the external conditions which prevail at the moment. When we are ignorant of the causes which are operative so long before the results are seen, we gain the impression that such variations as occur are spontaneous or autonomous expressions of the inner nature of the plant. It is much more likely that, as in Sempervivum, they were originally produced by an external stimulus which had previously reached the sexual cells or the young embryo.*" (Italics mine.)

All of which, although only drawn from individual cases, also refers to influences affecting a species. We are left to ponder over the relation of the "inner nature" of the plant to stimuli from outside. This relation somehow in the long run, we must assume, determines the definite tendencies of species and varieties. Whatever mysteries may be hidden in the "inner nature" of organisms, however miraculous the power of response, and however powerful the influence of the environment, I maintain that what count most in determining the main issue, *i.e.*, the definite tendency, the predominant behaviour and the success or otherwise of a species or a variety are the bio-economic factors. It is not for nothing that a variety responds "spontaneously" in one direction or another; its response is really largely pre-determined by its bio-economic

past. This being understood we may fitly view most tendencies of growth as the resultants of those positive and negative confluents, symbiotics and anti-biotics, in the dynamic make-up of organisms and species spoken of above.

Klebs also states:—"The regular fluctuation about a mean according to the rule of probability is often attributed to some law underlying variability. But there is no such law which forces a plant to vary in a particular manner, since every experimental investigation shows, as we have already observed, that the fluctuation of characters depends on fluctuations in external factors." But as fluctuations of "characters" depend, I believe, mainly on behaviour and bio-economic function, past and present—(a fact on which I must insist all the more, the less it is likely to be disclosed by laboratory methods)—it follows, in my view, that there is a perfect web of dynamics, constituted by the web of domestic and biological interactions, in which every organism and every species is involved; the degree to which they are involved determining and pre-determining all important developments and "tendencies." The law underlying variability, which Prof. Klebs totally fails to recognise, is the law of organic solidarity, involving the "law of bio-economic specialisation" and of symbiogenesis, and for the rest, so far as minor and local phenomena are concerned, the law of action and reaction. Many powerful components in the heritable dynamic constitution of a species are due to past ancestral endeavours, and the biological correlations they have established in the web of life; others are due to behaviour calculated to establish opposite effects. In any case the terms "symbiotics" and "anti-biotics" seem to be both, quantitatively and historically speaking, more adequate and more explanatory than the term "specific structure," which is vague. Prof. Klebs also states that "the historical sequence of *events of which the organism is the expression* (*italics mine*) can only be treated hypothetically with the help of factors supplied by comparative morphology, the history of development, geographical

distribution, and palæontology," but I maintain that beside and beyond these, the bio-economic past of a species is of the highest significance in that historical sequence of events and that its recognition will permit a more definite and rational account of the operation of biological dynamics than has hitherto obtained. Failing this recognition, Prof. Klebs is driven to speak of a mysterious "inner world" of organisms which is "hidden from our ken"; which I take to mean no more than the resultant effects of ancestral conduct and the accumulation of biological values.

To emphasize still more what it is thus intended to supply by the terms "symbiotics" and "anti-biotics," we may once more let Prof. Klebs speak.

The production of form in every plant depends upon processes in the interior of the cells, and the nature of these determines which among the possible characters is to be brought to light. In no single case are we acquainted with the internal process responsible for the production of a particular form. All possible factors may play a part, such as osmotic pressure, permeability of the protoplasm, the degree of concentration of the various chemical substances, etc.; all these factors should be included in the category of *internal conditions*. This inner world appears the more hidden from our ken because it is always represented by a certain definite state, whether we are dealing with a single cell or with a small group of cells. These have been produced from pre-existing cells and they in turn from others; the problem is constantly pushed back through a succession of generations until it becomes identified with that of the origin of species.

The problem of the origin of species is thus quite rightly seen to merge itself in that of form-production, which we have seen to be one of Bio-Economics and the related Bio-Chemistry. Hence the study of Bio-Economics is of the utmost importance as complementing that of comparative morphology, of the history of development, of palæontology, etc. Bio-Economics declare that it is work with its correlations and accumulations that determines form. Prof. Klebs unwittingly states, or rather implies, the same in so many words:—

The "inner world is not a constant factor: on the contrary, it appears to be very variable. The dependence of *variable internal* on

variable external conditions ("work" in action and reaction!) gives us the key with which research may open the door. In the lower plants this dependence is at once apparent, every cell being directly subject to external influences. In the higher plants with their different organs, these influences are transmitted to cells in course of development along exceedingly complex lines (establishment of ancestral dynamics!) In the case of the growing-point of a bud, which is capable of producing a complete plant (bearer of ancestral dynamics!) direct influences play a much less important part than those exerted through other organs, particularly through the roots and leaves, which are *essential in nutrition*. (*Italics mine.*)

The ancestral dynamics are the more powerful as reliable components the higher the organism in the scale of evolution, *i.e.*, the greater the fund of symbiotic values has become. Nutrition, as we have seen owing to its great bio-economic importance, is a powerful component and a powerful direct influence in its effects on roots and leaves and through those in the long run on the ensemble of the organism. It is intimately connected with work which is thus again seen to determine firstly, the direct reactions of organisation, and secondly and more slowly, by cumulative and correlated effects, the indirect and more complex reactions. A concentration of ancestral dynamics at the growing point is, of course, less readily affected by new work and new connected influences than a less concentrated and more virginal state at the outskirts. In other words, the effect of new forces is there less conspicuous, because they are acting upon a complex of stronger and more ancient (racial) forces than at the outskirts.

The same truth concerning the time-element in Bio-Dynamics is expressed thus by P. Kropotkin: "A rapidly established equilibrium of forces can be upset with the same rapidity, whilst an equilibrium of long standing requires a long time to be upset: this may be taken as a general law of Nature."

Klebs also mentions that "the state of the young rudiment is the outcome of previous influences of the external world communicated through other organs," which suggests

the combined dynamics of domestic and biological symbiosis and the dependence of all progressive development on symbiogenesis, and he further remarks that correlations must be conceived as "of the greatest importance as aids to an understanding of form-production," which we must now understand to mean biological as much as domestic correlations.

It is interesting that the same biologist who is so well qualified to express an opinion on these matters points out that: "According to the modern standpoint, the living cell is a complex chemico-physical system which is regarded as a dynamical system of equilibrium (a conception suggested by Herbert Spencer), which has acquired a constantly increasing importance in the light of modern developments in physical chemistry."

The dynamic view of organisation which, of course, was applied by Spencer also to complex organisms—moving equilibria—is thus in harmony with the views of modern experimental science. I claim that the demonstration of the bio-economic and symbiogenetic method by which accumulations of organic powers and organic wealth are achieved, makes the dynamic view which now commends itself to modern experimental morphologists much more acceptable. It will be worth while here to consider Herbert Spencer's dynamic views at some length and to see whither they must lead.

In his *Principles of Biology*, Herbert Spencer mentions the well-known facts that the actions of organisms entail reactions on them, and that specialities of action entail specialities of reaction. He adds, however: "Here it remains to be pointed out that the special actions and reactions do not end with temporary changes, but work permanent changes."

"Limited increase of size produced in any organ by a limited increase of its function, is not maintained unless the increase of function is permanent."

This fact we are all familiar with. Spencer also notes that: "It seems that in each species of organism, there is a margin for functional oscillations on all sides of a mean state,

and a consequent margin of structural variations; that it is possible rapidly to push functional and structural changes towards the extreme of this margin in any direction, both in an individual and in a race; but that to push these changes further in any direction, and so to alter the organism as to bring its mean state up to the extreme of the margin in that direction, is a comparatively slow process."

Here the great synthetic philosopher adds, parenthetically, he is assuming that "modifications of structure produced by modifications of function, are transmitted to offspring,"—the necessities of the argument having obliged him to assume the conclusion reached in a subsequent chapter.

With the facts, so far set before us, we are, of course, familiar, but seeing that they are deduced without regard to the concomitant bio-economic facts, *i.e.*, seeing that the organism is taken out from its *ensemble*, we are already on our guard against conclusions that are too mechanical.

So far as species-formation is concerned, the problem of problems, according to Spencer, is to achieve decided steps in any direction by a group of individuals, and that by involving them in a set of special actions and reactions of sufficient permanence and strength to bring about the necessarily slow process of raising the mean state up to the extreme of the margin in that direction. How is this done?

Spencer says: "Study the laws of organic modification."

"A right understanding of the laws of organic modification underlies a right understanding of the great question of species."

This is a somewhat similar statement to Samuel Butler's that "modification, like charity, begins at home"; except that Butler's view more pertinently points to the autonomous factor, to effort and work. That Spencer, notwithstanding his rigid mechanics, felt driven to admit or imply this factor, will be clear from the following. But for the fact that his general biological views were too mechanical, he might easily have discovered the wider dynamics underlying the web of life, for

the recognition of which he was otherwise so well equipped by his whole training. Let us see.

As regards the laws of organic modification—failing the bio-economic explanation—Spencer is somewhat at sea and can but “dimly discern a harmony” with his famous first principles.

“Why an organ exerted somewhat beyond its wont, should presently grow, thus meet increase of demand by increase of supply, is not obvious.” That excess of repair should succeed excess of waste, is to be expected. “But how happens the mean state of the organ to be changed? If daily extra waste naturally brings about daily extra repair only to an equivalent extent, the mean state of the organ should remain constant.”

Clearly we must look for an explanation somewhere outside Spencer’s *First Principles*. Indeed, he himself makes the attempt in what I consider to be the right direction, although being too much committed to his mechanical *First Principles* and to his definition of life, he shrinks from drawing the wider bio-economic conclusions, which nevertheless easily arise from the consideration he sets before us.

Says he :

Such answer to this question as we may hope to find, must be looked for in the effects wrought on the organism as a whole, by increased function in one of its parts. For since the discharge of its function by any part, is possible only on condition that those various other functions on which its own is immediately dependent, are also discharged; it follows that excess in its function presupposes some excess in their functions. Additional work given to a muscle implies additional work given to the branch arteries which bring it blood, and additional work—smaller in proportion—to the arteries from which these branch arteries come. Similarly, the smaller and larger veins which take away the blood, as well as the absorbents which carry off effete products, must have more to do. And yet further, on the nervous centres which excite the muscle, a certain extra duty must fall. But excess of waste will entail excess of repair in these parts as well as in the muscle. The several appliances by which the nutrition and excitation of an organ are carried on, must also be influenced by this rhythm of action and reaction and, therefore, after losing more than usual by the destructive process, they must gain more than usual by the constructive process.

But temporarily-increased efficiency in these appliances by which blood and nervous force are brought to an organ, will cause extra assimilation in the organ, beyond that required to balance its extra expenditure. Regarding the functions as constituting a moving equilibrium, we may say, that divergence of any function in the direction of increase causes the functions with which it is bound up to diverge in the same direction; that these again cause the functions which they are bound up with also to diverge in the same direction, and that these divergences of the connected functions allow the specially-affected function to be carried further in this direction than it could otherwise be—further than the perturbing force could carry it if it had a fixed basis.

He adds:

It must be admitted that this is but a vague explanation. That the facts are to be interpreted in *some such way*, may, however, be inferred from the circumstances that an extra supply of blood continues for some time to be sent to an organ that has been unusually exercised, and that when unusual exercise is long continued a permanent increase of vascularity results. (*Italics mine.*)

Spencer thus rightly points out, that we must study the organism as a whole. But I go further, and I insist that we must expand this idea and view the organism in its biological *ensemble*. Only if we learn to consider the phenomena here concerned in their biological entirety shall we arrive at correct interpretations.

The facts of co-ordination, of mutual dependence and of mutual support (unconscious co-operation) between organs, stand out very prominently in the above passage. An organism that manages to achieve such a high degree of co-operativeness—inseparable as we have seen this to be from bio-economic co-operativeness—as here depicted is on the way to transcend itself, is indeed a transformed higher species as compared with a previous stage of less efficient, less complete co-operation. We have seen this to be so in the case of plantagens and also in the case of amphimixis. If the extra work of one organ is able to stimulate the remaining organs sympathetically in the direction of a genuinely increased output of “work” generally, we have here an example of economic activity and its good effects of precisely the same nature—only different in

degree—as among human societies. It might have occurred to Spencer that in view of the inter-dependence of life, the benefit to the organic community at large of any particular output of “work” by a unit, might be such as to lead by way of reaction to bio-economic compensations.

That those parts of a community which are the most genuinely active in the production of “wealth” should be the subjects of the most universal concern on the part of others benefitting thereby, and consequently the most remunerated, would seem to be in agreement, if not with Herbert Spencer’s “first principles,” yet with the principles of economics, of equity and of self-preservation, and without being, for that matter, opposed to dynamics.

That everywhere in nature the utmost care is bestowed upon the maintenance of the most valuable parts, that the less important parts normally everywhere act as servants to the more important, is easily demonstrable. There are the well-known facts of vicarious action on the part of cells and of nerve-fibres. The asexually reproducing cells of a flowering plant, as we have seen, merely remain hewers of wood and drawers of water for their gorgeously-attired sisters which have attained to the power of sexual reproduction (resulting in a bio-economic status higher than that warranted by the asexual condition). The virgin bee workers recognise the queen as a symbol of life more precious, more vast than their own. They will sacrifice their lives for the sake of hers. Again we find that the more permanently valuable parts of a body are most carefully isolated. The heart, the brain, and the germ substance may serve as instances.

The heart and connected vessels are so arranged that the best blood goes to the head, and in a similar manner we find in social life that the inferior must infallibly serve the superior—the kings or “cunnings,” *i.e.*, those that “can.” It is only prejudice which denies that we are justified in looking upon the activities of organisms as “work,” and upon results as remuneration in the economic sense of the term.

As regards, once more, the problem of involving a species in a new set of special actions and reactions of sufficient permanence and strength to bring about the necessarily slow process of raising its mean state up to the extreme margin in a particular direction, we shall now place our reliance primarily upon those systematic activities which partake most unmistakeably of the character of "work" (such as that of the roots and leaves of a tree, for instance), which manifestly involves Bio-Economics.

A tree that "works" establishes symbiotics and is of immense bio-economic usefulness. It is not to be wondered at if the web of life in turn confers advantages and "remunerations" upon such a useful member. We have a conspicuous example of return of service in the cross-fertilisation of trees by animal agency, which in view of the advantages it confers all round is a genuine instance of symbiogenesis. The work of the tree, we may say, increases its own capital *pari passu* with that of the organic world. On the other hand, organisms which do not work are obliged to live on capital, and to encroach upon the rights of others. Again, we cannot be surprised if such specialty of retrograde action must, and does, in fact, entail a specialty of (retrograde) reaction, which may eventually become cumulative and thus disastrous. If in the latter case, the change produced in the negative direction is at first not so obviously rapid as to enable us to distinguish it at a glance from the necessarily slow change going forward in the progressive types, this is only because the bond of a former (slowly accumulated) utility binding together the various parts remains automatically operative for some considerable time, or because, frequently, some kind of utility still remains. "Selbst die Hoelle hat ihre Rechte." Even degeneration has its laws. Once, however, degeneration is well started it develops at a phenomenal rate—depravity runs swifter than death, according to Socrates—and it then no longer leaves us in doubt as regards its true anti-symbiotic character and its true value in evolution.

To the question why in individual descendants of animals the limit of modification is but slowly extended, Herbert Spencer replies "that there are required numerous and widespread modifications." In other words, there is a plurality of correspondences and correlations to be considered. With his usual brilliancy and wealth of illustration, Spencer shows how these correspondences work out in the purely physiological sphere. He takes no account, however, of the most essential of all, viz., the bio-economic sphere and its correspondences, which latter primarily determine the constancy or otherwise of all equilibria concerned.

Before the artery which feeds a hard-worked muscle can permanently furnish a large additional quantity of blood it must increase in diameter and contractile power, and that its increase of diameter and contractile power may be of use the main artery from which it diverges must also be so far modified as to bring this additional quantity of blood to the branch artery. Similarly with the veins, similarly with the absorbents, similarly with the nerves. And when we ask what these subsidiary changes imply, we are forced to conclude that there must be an analogous group of more numerous changes, ramifying throughout the system. The growth of the arteries primarily and secondarily implicated cannot go to any extent without growth in the minor blood-vessels on which their nutrition depends, while their greater contractile power involves enlargement of the nerves which excite them and some modification of that part of the spinal cord whence these nerves proceed. Thus, without tracing the like remote alterations implied by extra growth of the veins, absorbents and other agencies, it is manifest that a large amount of rebuilding must be done throughout the organism before any organ of importance can be permanently increased in size and power to a great extent. Hence, though such extra growth in any part as does not necessitate considerable changes throughout the rest of the organism may rapidly take place, a further growth in this part, requiring a remodeling of numerous parts remotely and slightly affected, must take place but slowly.

Although Spencer does not perceive that nutrition which here comes in without proper introduction is primarily determined by work, yet this passage marks a noticeable approach to our bio-economic theory, so long as we tacitly imply that the organism having need of food and of occasional rebuilding

manages somehow to produce the necessary purchase consideration, which involves biological co-operation and concomitant degrees of general physiological efficiency and integrity.

Once more it becomes clear that no genuine advancement can take place without all parts concerned performing to the fullest the duties which have devolved upon them, and which they are best qualified to perform. The very fact that the more complex the organisation, the more costly the expenditure required to achieve progress, also shows that the higher the organism stands in the scale of evolution, the more pronounced becomes the need of general restraint incumbent upon it—the truth of the physiological application of the aphorism “noblesse oblige” is once more shown.

How narrowly Spencer missed *Bio-Economics* will be seen from the following analogy that he draws between adaptive modifications in organisms on the one hand, and in human societies on the other:—

We have before found our conceptions of vital processes made clearer by studying analogous social processes. In societies there is a mutual dependence of functions essentially like that which exists in organisms, and there is also an essentially like reaction of function on structures. From the laws of adaptive modification in societies we may therefore hope to get a clue to the laws of adaptive modification in organisms. Let us suppose, then, that a society has arrived at a state of equilibrium like that of a mature animal—a state not like our own in which growth and structural development are rapidly going on,—but a state of settled balance among the functional powers of the various classes and industrial bodies and a consequent fixity in the relative sizes of such classes and bodies. Further, let us suppose that in a society thus balanced, there occurs something which throws an unusual demand on some one industry—say, an unusual demand for ships (which we will assume to be built of iron) in consequence of a competing mercantile nation having been prostrated by famine or pestilence. The immediate result of this additional demand for iron ships is the employment of more workmen and the purchase of more iron by the ship-builders, and when, presently, the demand continuing, the builders find their premises and machinery insufficient, they enlarge them. If the extra requirement persists, the high interest and high wages bring such extra capital and labour into the business as are needed for new ship-building establishments. But such extra capital and labour do not come quickly, since, in a balanced

community, not increasing in population and wealth, labour and capital have to be drawn from other industries where they are already yielding the ordinary returns. Let us now go a step further. Suppose that this iron ship-building industry, having enlarged as much as the available capital and labour permit, is still unequal to the demand, what limits its immediate further growth? The lack of iron. By the hypothesis, the iron-producing industry, like all the other industries throughout the community, yields only as much iron as is habitually required for all the purposes to which iron is applied: ship-building being only one. If, then, extra iron is required for ship-building, the first effect is to withdraw part of the iron habitually consumed for other purposes and to raise the price of iron. Presently, the iron-makers feel this change and their stocks dwindle. As, however, the quantity of iron required for ship-building forms but a small part of the total quantity required for all purposes, the extra demand on the iron-makers can be nothing like so great in proportion as is the extra demand on the ship-builders. Whence it follows that there will be much less tendency to an immediate enlargement of the iron-producing industry—the extra quantity will for some time be obtained by working extra hours. Nevertheless, if, as fast as more iron can be thus supplied, the ship-building industry goes on growing—if, consequently, the iron-makers experience a permanently increased demand, and out of their greater profits get higher interest on capital as well as pay higher wages, there will eventually be an abstraction of capital and labour from other industries to enlarge the iron-producing industry; new blast-furnaces, new rolling-mills, new cottages for workmen, will be erected. But obviously, the inertia of capital and labour to be overcome before the iron-producing industry can grow by a decrease of some other industries, will prevent its growth from taking place until long after the increased ship-building industry has demanded it, and meanwhile, the growth of the ship-building industry must be limited by the deficiency of iron. A remoter restraint of the same nature meets us if we go a step further—a restraint which can be overcome only in a still longer time. For the manufacture of iron depends on the supply of coal. The production of coal being previously in equilibrium with the consumption, and the consumption of coal for the manufacture of iron being but a small part of the total consumption, it follows that a considerable extension of the iron manufacture, when it at length takes place, will cause but a comparatively small additional demand on the coal-owners and coal-miners—a demand which will not, for a long period, suffice to cause enlargement of the coal trade by drawing capital and labour from other investments and occupations. And until the permanent extra demand for coal has become great enough to draw from other investments and occupations sufficient capital and labour to sink new mines, the increasing production of iron

must be restricted by the scarcity of coal, and the multiplication of ship-yards and ship-builders must be checked by the want of iron. Thus, in a community which has reached a state of moving equilibrium, though any one industry directly affected by an additional demand, may rapidly undergo a small extra growth, yet a growth beyond this requiring, as it does, the building-up of subservient industries less directly and strongly affected, as well as the partial unbuilding of other industries, can take place only with comparative slowness. And a still further growth, requiring structural modifications of industries still more distantly affected, must take place still more slowly.

The well-known complexity of the web of life is thus strikingly brought home to us, though even so with some important omissions. Thus "a competing mercantile nation," though it may be "temporarily prostrated by famine or pestilence," certainly is one that normally relies upon a certain amount of international trade, *i.e.*, on give and take between nations. A mere competitive advantage gained over another nation is only an apparent advantage. The true advantage is the co-operative advantage. The true advantage taken of a prostrate nation by temporarily supplying its needs, for instance, is to gain a co-operative return of service as soon as that nation's capacities for reciprocal activities are fully restored.

The gain is the greater, as the rejuvenated nation in all probability will make the greater efforts not to remain a debtor nation long and give of its own genius, thus making invaluable contributions to the general welfare of the community of nations.

The gain of a nation relying upon international trust and international exchange frequently is enormous, and it does not depend, as Spencer would seem to suggest, on the prostration of another nation, but, on the contrary, on the prosperity of other nations* on their capacity to co-operate, to give, and to

* This idea is made much clearer and more cogent if we get rid of the common notion of a nation being like a manufacturer selling to an outside public and competing with other manufacturers for the public's patronage; and substitute the true idea that the nations are a group of manufacturers, and there is no outside public. Then it is abundantly clear that the more each can produce of his own the more he will be able to buy of others, produce by exchange. The co-operative nature, the mutuality of international trade is thus shown in contrast to the competitive view of it commonly entertained.

exchange services. The example shows, indeed, that the rate of progress in human as well as in organic life can be quickened—as it actually and constantly is being quickened—by extending the borders of co-operation. The nation that has stepped into the breach owing to a misfortune of another nation is not dependent for all future time on its own resources, but will soon be in a position to depend increasingly on the surplus resources of other nations. What is more, efficiency and knowledge are everywhere increasing fast where increasing co-operation, with increasing security of life and a consequent increasing reliance upon a variety of reciprocal differentiations (specialisations), are becoming the rule of life. The expert knowledge gained by the members of one nation thus adds continually to the store of knowledge already shared by all. Spencer's view of adaptation and of species formation thus, in spite of an otherwise well-selected analogy, remains too local, too narrow. A better view of adaptation is that of Prof. Eimer, who remarks that the individual is not necessarily constructed entirely in accordance with its own requirements. "Only an inconceivably gross egoism could seriously make this assumption—the individual is nothing but a wheel in the clock-work of the universe; to the universe its characters must be adapted; for the wheel, for the individual itself, only such a proportion of advantage is possible as the order of the whole allows, as in this order belongs to it."

That mere mechanical explanations are insufficient will become clearer still from the following of Spencer's considerations regarding "growth." He tells us that:—

"Growth is a concomitant of Evolution; and if Evolution of one kind or other is universal, growth is universal," and, further, that where the growth is to become great, there exists to start with a well-developed embryo and a stock of assimilable matter. "Where great bulk is to be reached, the young proceeds from an egg of considerable bulk, or is born of considerable bulk ready organised and partially active." "Beyond the mass and organisation directly bequeathed, a bird or

mammal (in virtue of suckling and feeding by the parents) obtains a further large mass at but little cost to itself."

But if, according to Spencer, the size ultimately attained by an organism is frequently determined by the initial size, he is not oblivious of the fact that there must exist a certain dependence of growth on organisation. In plants, for instance, "we see that for the attainment of great bulk there is required such a degree of organisation as shall co-ordinate the functions of roots and branches—we see that such a size as is reached by trees is *not possible without an efficient vascular system enabling the remote organs to utilise each other's products.*" (Italics mine.)

I have already referred to the need of a permanent increase of vascularity in the progressive evolution of plants and to its association with "work."

With all his comprehensiveness, Spencer here again contents himself with too statical a view, although, as usual, much more may be gleaned from his illustrations. Clearly the very provision of an initial outlay which subsequently proves so important for individual growth is primarily a matter of function and depending in particular for its bio-chemical adequacy on the general degree of productiveness of the particular species. The great and universal necessity of all organisms to be passed through the unicellular condition—to partake of the beneficence of the fertilisation process—is attended by the simultaneous requirement of all organisms to provide from their own flesh and blood the embryonic nutrition, qualitatively as well as quantitatively, and the general embryonic equipment of their progeny, and thus to determine by means of transmitted biological values the life of the latter to a large degree. There is no shirking in these matters, and every pronounced physiological deficiency emanating from a lapse of work is thus bound to be communicated to the germ. "I will visit upon you the sins of your fathers unto the third and fourth generation." It is quality, moreover, that is normally required rather than quantity. Wherever the

morbidity of in-feeding species, for instance, has become so great as to demand excessive amounts of embryonic supplies (regardless of quality), we may take it that this unenviable requirement, which in some cases may lead to the sacrifice or the devouring of the mother by the young, in itself in turn becomes a cumulative cause of a further extension of the fatal habit of depredation. If in the case of a degenerate the embryo obtains "a large mass at but little cost to itself," this is not by any means always to its true good. Neither is it altogether so unconnected with the usual chain of economic cause and effect as Spencer's innocent looking passage would make us believe. Both the adult's and the embryo's surfeit (only required in the given case because of a morbid appetite due to bad habits) are obtained by depredation, and, hence, spell a loss of ancestral dynamics, with resulting further general deterioration of character. That it is which matters, and matters most in the long run. Without such distinctions we shall mix up indiscriminately different orders of facts.

To what an extent organisation determines growth, Spencer is unable to tell us, failing bio-economic orientation. Clearly, if the bulk of a tree depends on an efficient vascular system enabling the remote organs to utilise each other's products, the success of the tree is largely due to the efficient co-operation of all the parts, to the concomitant efficiency of its apparatus for drawing on soil and atmosphere for sustenance, and—last, not least—to the cumulative good effects (and biological reactions) of such wholesome bio-economic activities accruing in course of time. In other words, the tree's character is its first wealth, and forms its main reliance for status and survival, its justification for what bulk it legitimately requires.

The qualified dependence of growth on organisation might indeed have easily become a much stronger point with Spencer but for the fact that it is "traversed and obscured by sundry other relations," which relations, of course, proved too intricate for him to disentangle without the aid of a proper

biological analysis. As it is we must marvel at his profound insight which allowed him to give so nearly accurate a place to a number of potent and pertinent biological factors. He states that:—

It is clear that for an equally efficient maintenance of their nutrition the parts of a large mass must have a more elaborate propelling and conducting apparatus, and that in proportion as these parts undergo greater waste, a yet higher development of the vascular system is necessitated.

In plants the

Formation of a core of regularly-arranged woody fibres is an advance of organisation.

Throughout the animal kingdom this connection of phenomena is manifest. To obtain materials for growth, to avoid injuries which interfere with growth, and to escape those enemies which bring growth to a sudden end implies, in the organism, the means of fitting its movements to meet numerous external co-existences and sequences—implies such various structural arrangements as shall make possible these variously-adapted actions. It cannot be questioned that, everything else remaining constant, a more complex animal, capable of adjusting its conduct to a greater number of surrounding contingencies, will be the better able to secure food and evade damage, and so to increase bulk. And, evidently, without any qualification, we may say that a large animal, living under such complex conditions of existence as everywhere obtain, is not possible without comparatively high organisation.

As soon as we supplement this by the necessary bio-economic inferences, we thus see that the dependence of growth on organisation becomes much more evident, and, what is more, that, indeed, all developments of importance—form and evolution itself—ultimately depend on work.

A more elaborate propelling and conducting apparatus is able to support a stronger skeleton, and this, in turn, can perform greater economic services, better work of all kinds, the results of which are exchangeable as in international trade. Woody fibres resulting from increased domestic work of the plant are, in turn, of immense bio-economic use, and, in general, the activities of a tree rich in regularly arranged woody fibres and with an elaborate vascular system are of enormous bio-economic importance. Further, and as we have

seen, those types of organism which are most efficient in symbiotic labour are also most efficient in symbiotic respiration and in providing embryonic nutrition, some of which, at any rate as "love-food," can be spared for the purposes of exchange with other organisms. Moreover, the most efficient producers and traders among organisms are also the most capable of avoiding injuries and of avoiding or escaping enemies; partly because of the sympathy they enjoy, the non-aggressiveness of their character, the indispensability of their services, the integrity of their composition; and partly because of the superiority of their intelligence and of their social organisation, their general capacity of controlling rather than being controlled by the contingencies of their existence. Many animal organisms, it is true, are predaceous plant-feeders, and frequently the depredation of herbivores has been responsible for the absence of trees and shrubs over a wide area. But obviously, taken as a whole, the animal kingdom has no real cause to prevent trees from securing their food by drawing on the soil and so increasing their bulk. There is no real clash of interests. On the contrary, in the long run, it is to the animal's advantage that the tree should be allowed duly to perform its labours, and that this is so, that the tree has so much to offer to make its existence desirable must be—and is in practice—an additional advantage to the tree.

That some amount of *qualification* as regards the supply of assimilable matter required to produce growth is necessary had not totally escaped Spencer. But it has never dawned upon him that there are vitally important bio-economic factors involved in the production and utilisation of food. He tells us, indeed, that "the value of food for purposes of growth depends not on the quantity of the various organisable materials it contains, but on the quantity of the material most needed (quality!), that given a right proportion of materials the pre-existing structure of the organism limits their availability, and that the higher the structure the sooner is this limit reached."

This is, indeed, an adumbration of the view that an important correlation exists between organisation and food, and that the higher the organism the more discriminating it has to be in its choice of foods.

Have all animals equal surplus of assimilative power (asks Spencer), and, if not, how far do differences between the surpluses determine differences between the limits of growth? . . . For example, an ox immensely exceeds a sheep in mass. Yet the two live from generation to generation in the same fields, eat the same grass and turnips, obtain these aliments with the same small expenditure of force, and differ scarcely at all in their degrees of organisation. Whence arises, then, their striking unlikeness of bulk?

We noted when studying the phenomena of growth inductively, that organisms of the larger and higher types commence their separate existences as masses of organic matter having tolerable magnitudes. Speaking generally, we saw that throughout each organic sub-kingdom the acquirement of great bulk occurs only where the incipient bulk and organisation are considerable, and that they are the more considerable in proportion to the complexity of the life which the organism is to lead.

The deductive interpretation of this induction may best be commenced by an analogy. A street orange-vendor makes but a trifling profit on each transaction and, unless more than ordinarily fortunate, he is unable to realise during the day a larger amount than will meet his wants: leaving him to start on the morrow in the same condition as before. The trade of the huxter in ounces of tea and half-pounds of sugar is one similarly entailing much labour for small returns. Beginning with a capital of a few pounds, it is impossible for him to have a shop large enough, or goods sufficiently abundant and various, to permit an extensive business: he must be content with the halfpence and pence which he makes by little sales to poor people; and if, avoiding bad debts, he is able by strict economy to accumulate anything, it can be but a trifle. A large retail trader is obliged to lay out much money in fitting up an adequate establishment, he must invest a still greater sum in stock, and he must have a further floating capital to meet the charges that fall due before his returns come in. Setting out, however, with means enough for these purposes, he is able to make numerous and comparatively large sales, and so to get greater and more numerous increments of profit. Similarly, to get returns in thousands, merchants and manufacturers must make their investments in tens of thousands. In brief, the rate at which a man's wealth accumulates is measured by the surplus of income over expenditure, and this, save in exceptionally favourable cases, is determined by the capital with which he begins

business. Now applying the analogy, we may trace in the transactions of an organism the same three ultimate elements. There is the expenditure required for the obtainment and digestion of food, there is the gross return in the shape of nutriment assimilated, or fit for assimilation, and there is the difference between this gross return of nutriment and the nutriment that was used up in the labour of securing it—a difference which may be a profit or a loss. Clearly, however, a surplus implies that the force expended is less than the force latent in the assimilated food. Clearly, too, the increment of growth is limited to the amount of this surplus of income over expenditure; so that large growth implies both that the excess of nutrition over waste shall be relatively considerable, and that the waste and nutrition shall be on extensive scales. And clearly, the ability of an organism to expend largely and assimilate largely, so as to make a large surplus, presupposes a large physiological capital in the shape of organic matter more or less complete in its structural arrangements.

And thus Spencer thinks he has acquitted himself of the task of showing how, speaking generally, throughout each organic sub-kingdom, the acquirement of great bulk occurs only where the incipient bulk and organisation are considerable, and that they are the more considerable in proportion to the complexity of the life “which the organism is to lead.”

Again the general analogy is well chosen. It is calculated to open up the rich field of economics. But Spencer shirks a profound economic interpretation. Moreover, like Darwin in the case of Natural Selection and variations, he begs the real question, which is the question of “origins.” Just as, according to Samuel Butler, the results ensuing on Natural Selection “will depend entirely on what it is that is selected from,” so all physiological capital ultimately depends on positive ancestral dynamics, *i.e.*, on symbiotics.

Grant but the “luck” of a good start, though but as a street-vendor, and the rest is comparatively easy; although, as things are at the present day, even so lucky a capitalist will, in all probability, at the end of, say, twenty years of business—unless extraordinarily lucky—not have an accumulation to compare with that of some City alderman, more careful or more “lucky” in the choice of his parents. What of the

street-vendor's "cunning," Samuel Butler would probably have asked, in obtaining even his moderate start?

Spencer, together with some of his illustrious contemporaries—less democratic in feeling than we are at the present day—seems on the whole to have been content with a kind of middle-class philosophy, to the effect that every organism (or man) with any decency in him will have been so "well-born" as to have a pretty good incipient capital to start with. All capital, however small and of whatever kind, in human as well as in organic civilisation, is primarily obtained by work, and represents ancestral dynamics and the accumulations due to symbiosis. To know the nature of these dynamics in each case is to understand organisation with its subsequent developments, variations, and adaptations, and also its eventual fate.

In order to understand the "striking unlikeness of bulk" between an ox and a sheep, although in domestication they feed and they do pretty much alike, we must go back to ancestral dynamics, when we shall find that, as in the case of the two species *Convoluta*, the differences are ultimately connected with differences of nutrition, *i.e.*, with metabolic differences, and in the last analysis also with differences of symbiotic behaviour and of symbiotic activities.

Spencer views all these matters too narrowly and too statically. These different types probably had a common ancestor, and hence must have been much more alike at one period. It was through subsequent differences of conduct and also of circumstances that they first became of different size and form. That subsequent and more recent dynamics, if they produce a great similarity of external effects, as in domestication, must again lead to striking parallelisms and similarities of structure, is amply borne out by the well-known phenomena of convergence.

Spencer's analogy concerning the bequeathing of physiological and trade capital needs the qualification that good and normal results can only accrue with right use. The accumulation

of capital involved, as we have seen, from the first a production of (exchangeable) values over and above the personal needs, which thus obviously had to be restrained in view of the desired or required surplus. It also involved beyond this indispensable adequacy of physiological, and more than physiological, trade economy, the presence of other organisms equally prepared, equally sympathetic, and thus equally deserving of mutual forbearance. It is in virtue of an adequate participation in this universal scheme of labour, of give and take, of live and let live, that organisms are able to accumulate and to retain wealth. It is true of such honest acquisitions that "Unto everyone that hath shall be given, and he shall have abundance," as it is also inversely true of the degenerate, who does not strive to maintain positive ancestral dynamics, seeing that he thus surrenders vital symbiotic correlations, that "from him that hath not shall be taken away even that which he hath."

What is essential above all in wealth getting is that the community as a whole benefits from the activities of the respective members. And it is here where we must draw the line, however big the "initial outlay." The ultimate fate of a trader, in nature as in human life, depends not so much on the lavishness of his capital, as on its general serviceableness. The particular trade came into existence because of its usefulness. It spread successfully because of the usefulness of the relations which the trader was capable, wise, and sympathetic enough to establish with others. It is the *setting up of useful and proper relations* which thus from the first produces success and survival.

The possession of capital thus entails essential restraints, and where they are not observed we get monstrous and undesirable growths. "Woe to him that increaseth that which is not his; and to him that ladeth himself with thick clay." Such distinctions, however, Spencer did not see fit to make, though he could not but dimly feel that there exists a certain incongruity in the very choice of his illustrations. "Confirming

and conflicting in endless different ways and degrees," he says in his conclusion, "are the several conditions by which the phenomena of growth are governed." In no case can a desirable "surplus of income over expenditure" be successfully achieved by depredation. Spencer, nevertheless, thinks it can be done. He says:—

Manifestly the young lion, born of tolerable bulk, suckled until much bigger, and fed until half grown, is enabled by the power and organisation which he thus gets gratis, to catch and kill animals of size enough to give him the large supply of nutriment needed to meet his large expenditure and yet leave a large surplus for growth.

What manner of "growth," what manner of "large expenditure," what manner of "gratis" benefit does the lion get, indeed? And what is its success in organic civilisation? As a mammal the lion, of course, has a considerable fund of positive ancestral dynamics to rely upon, and can thus indulge in morbid feeding habits (with resultant morbid developments of size) for considerable periods of time, though probably short as compared with the geological time covering the positive dynamics and the life-period of the common mammalian ancestor. A certain amount of *joie de vivre* and of healthy exercise of some few powers, at any rate, no doubt tend somewhat to prolong the length of days of the species lion. But it is the morbid "requirements" of this fastidious beast which make it a pest and render its existence in an ever advancing organic civilisation increasingly impossible. This is so also, because, in spite of all appearances to the contrary, the great bulk of animals of the predaceous type is in reality achieved at the expense of physiological capital, as I have sought to show in my *Evolution by Co-operation*.

I have there also pointed out that the fate now threatening the species lion presents a parallel to that of the Arab tribes of the Mogreb, who from a race of predatory exploiters became transformed into a race of mere parasites, their remnants now constituting those unfortunates whom the cultivators call *Ben ramassés* — without a means of livelihood save begging,

prostitution, and every variety of crime. The case of the lion perhaps does not stand quite so badly as that of the *Ben ramassés*—man frequently using his endowment, as Goethe says, in order to be “tierischer als jedes Tier”—but in either case we have here the final result of bio-economic conduct which is decidedly negative. In either case the spirit of the prophet Habakkuk's words very aptly applies: “Because thou hast spoiled many nations, all the remnant of the people shall spoil thee.”

As soon as he comes to deal with normal life, with consequent normal growth, Spencer is unable to introduce his illustrations quite so “manifestly” as in the case of the lion, but has to admit, on the contrary, that in such instances “the premises of the above argument (concerning the trade of the street-vendor or huxter) are but very partially fulfilled.”

“Throughout the vegetable kingdom, the illustrations of this truth are not conspicuous and regular: the obvious reason being that plants are accumulators and in so small a degree expenders.”

The expenditure and requirements of a photosynthetic plant are reasonable and in keeping with its bio-economic tasks. So far from being a spendthrift, it achieves surplus and supplies the biological world with a large amount of physiological values with a minimum amount of waste and cost. What reason is there why its growth should be arrested by “the equilibration of assimilation and waste,” so long as it maintains its positive ancestral dynamics; so long as it, on the whole, maintains a wholesome surplusage of work? A tree, as Spencer admits, enjoys almost unlimited growth. It may annually send forth new shoots, even when the trunk is hollowed out by decay. And why should it not so long as it remains truly useful?

It is wrong to think, as some biologists do, that the Malthusian doctrine anent population and the “struggle for existence” is all that need to be taken into account in speaking of the economy of Nature, and that it affords an unassailable

basis for a valid theory of evolution. It is a one-sided acceptance of Malthus and a tacit rejection of Adam Smith with his teaching of work as the sole basis of wealth. Not only does it falsely give an inferior place to work and to co-operation as compared with competition, but it ignores these positive factors altogether. Such incompleteness of thought has been too long the bane of Biology, *with the result that the true issue, viz., the study of values, has been obscured.* Yet from the first to the last, *I affirm that everything in Biology is a matter of values, and not merely of numbers.*

Spencer's work presents a striking illustration of the incongruities that were bound to arise in the absence of a qualitative biological analysis. Very justly he has told us in his *First Principles* that, "to see clearly how a right or wrong act generates consequences, internal and external, that go on branching out more widely as years progress, requires a rare power of analysis." Yet in his own case, for lack of appreciation of qualitative differences between biological conditions apparently similar, he is surprised to find facts—say of nutrition—producing what seem to him contradictory results on different organisms. That is to say he ranks equally as "abundant nutrition" the surplus gained by an organism strenuously earning its living by normal and healthful activity and the mere surfeit produced by a predaceous or parasitic gorging of food without adequate exertion and its healthful reactions. No wonder in the end he is baffled and speaks of "conspiring" and endlessly "conflicting" degrees of conditions by which the phenomena of growth are "governed."

Whilst the case of the ox, the sheep, the lion, and (though less readily) that of the plant seemed to fall in with his analysis, he has some difficulty with the case of the crocodile, which "is said to grow as long as it lives." Moreover, "there appears reason to think that some predaceous fishes, such as the pike, do the same." What does he say is the explanation? "That these animals of comparatively high organisation have no definite limits of growth is, however, an exceptional fact

due to the exceptional non-fulfilment of those conditions which entail limitation. What kind of life does a crocodile lead”?

Spencer here, indeed, puts the most pertinent question concerning the conditions of growth, and he implies, or rather concedes, that there may be exceptional (abnormal) habits of life calculated to set at nought such wholesome restraints and checks of bulk, incidental upon symbiotic activity, as we find to be the rule amongst normal organisms. This belated recognition, however, he uses too little and nowhere to the extent which it deserves.

What kind of life, indeed, does a crocodile lead?

This cold-blooded, or almost cold-blooded creature, he tells us, will not even undergo much exertion in catching its prey. Consequently it expends very little for the maintenance of heat. In short, “the mechanical causes necessitating a limit are here only partially in action.” And thus, as is usual with Spencer, instead of an inquiry into the significance of habits, the whole matter is considered on purely mechanical grounds, although quite obviously they offer but a fractional explanation of the phenomena concerned. “The exceptional continuance of growth observed in creatures so circumstanced (?) is therefore perfectly explicable.”

But though abnormally increasing bulk may have its relations, in Spencerian parlance, to “gravitational forces,” and also to powers that increase as the “cubes of dimensions,” it must also have important relations with other developments, it must be associated also with definite qualitative physiological or pathological, with bio-economic and psychological changes. As regards these important relations, however, Spencer is silent. Nor was the importance of symbiosis apparent enough in his days to permit of a proper analytical method of dealing with the dynamics of growth.

Let us now take some concrete cases of the practical utilisation of positive ancestral dynamics. And, first, as to the significance of “*grafting*.”

In a discourse on Horticultural Investigations at the Woburn Experimental Fruit Farm, delivered at the Royal Institution on Friday, February 21st, reported in *Nature* (28/8/13, page 675), Mr. Spencer U. Pickering, F.R.S., tells us:—

As it is impossible to reproduce a fruit-tree of any given variety from seed, other methods of multiplication must be adopted, namely, budding or grafting. A young tree of a similar character is taken (the stock), and in the one case a bud or, in the other case a twig (scion), from the tree to be propagated is united with the stem of the stock. All the growth arising from this bud, or buds, is similar to that of the tree from which it was taken; the stock acts as little else than a channel for conveying nourishment to the ingrafted buds, yet it does exert a certain influence on the character of the growth of the scion. For apples, we use two classes of stocks: the one, the crab stock, is obtained by sowing the seeds of crab-apples, and is characterised by forming a scanty number of roots, but these are stout and have a tendency to obtain deep hold of the ground; the other, the paradise stock, is derived from a French variety of apple, and forms a much larger number of roots, but smaller, and tending to spread out near the surface of the ground. The grafted tree partakes of the character of the roots of the stock: on the paradise stock it becomes more spreading in its habit and grows less vigorously than on the crab stock, and whilst the former is more suitable for growing trees in the bush form, the crab stock is more suited for standard trees.

What emerges is this: Originally, and for vast periods of time, the apple tree was capable of reproducing from seed. Before its character was changed by cultivation it drew on the (unsurfeited) soil, thus performing wholesome physiological labour, which conduced to a considerable degree of strength and vitality with corresponding bulk, and this *pari passu* with an increasing degree of bio-economic usefulness and of survival capacity. Now the cultivated apple has lost its power, but it is to these inherited endowments, *i.e.*, to the wholesome Bio-Dynamics (symbiotics) of the species apple still retained by the robuster wild stocks, that we have recourse for the rejuvenescence of our otherwise degenerating apple-trees. Domestication, which, according to Prof. Punnett, is frequently a process of continuous loss, so far as ancestral

characters are concerned, though it lead to an output of fruit increased in bulk and in numbers and even in some qualities, yet deleteriously affects the true and permanent interests of the tree, because it is apt to carry the exhaustion of the inherited racial capital (symbiotics) too far. This one-sided arrangement has arisen from greediness of man. The scion lives almost as an epiphyte on the stock. It obtains essential nutrition without effort, and can thus continue diverting its main energies in the direction of abnormal, *i.e.*, surfeited reproduction. The process is equivalent to a partial restoration of symbiotics.

The scion obtains enhanced facilities of nutrition which are not altogether for its good, though in view of the otherwise undoubted adequacy and compatibility of this particular nutrition, the scion is bound to obtain, at any rate for a time, some rejuvenation from it. The scion obtains what we might, in common parlance, describe as "new blood," although in reality it is "old blood," *i.e.*, congenial blood. The adequacy of the new strains of "blood" which the scion receives from the stock depends, of course, on the fact of common descent, a wild stock being chosen whose ratio of growth is fairly compatible with that of the scion. That the scion does not lose its characteristics, but just sufficiently retains them not to become completely merged in or blended with those of the stock, is not so astonishing when we remember that in "grafting" we generally choose precisely those compatibilities and precisely those methods which obviate such an event.

All that we wish to contrive is somewhat to replenish the exhaustion of the more dependent (over-nurtured) variety—in which we have a special gastronomic interest—by drawing on the virgin vitality of the independent variety. The ensuing exploitation of the latter seems to us a matter of indifference so long as nature provides an ample supply of "eternal givers." "Be sure they sleep not whom God needs." There is, however, a pretty general feeling among horticulturists that plants suffer from long-continued asexual

propagation by buds, cuttings, and grafts alone, and Prof. M. Hartog tells us:—

Many much-prized varieties of our fruit trees seem to be on the wane from this cause. Here, in Ireland, the Champion potato, from its resistance to the blight, was largely cultivated for many years, but we have seen it in turn lose its resisting powers after several years of propagation by “sets.”

Some little time ago when visiting the John Innes Horticultural Institution at Merton Park, where Prof. Bateson and his staff are conducting investigations in genetics and in the problems of sex characters and hybridization in plants, I was struck by the graceful appearance of certain calceolaria hybrids, and as the *Times* (20/7/14) says:—

Most of these are the results of experiments with *C. cana*, an unattractive, primitive-looking thing with woolly leaves which only a botanist would guess to be a calceolaria.

So far as is known, *C. cana* has not heretofore been used in crossing, but some of the hybrids from it are of great beauty, tall, branching plants of the “tree” type of novel shades of mauve and lavender and other curious tints.

Thus, again, we see that the wild or independent stock, *i.e.*, the plant that remained tolerably faithful within the bond of symbiogenesis—although quite inconspicuous—is yet superior to cultivated plants in positive ancestral dynamics (symbiotics). We make “practical” use of the latter by bringing wild plants into cultivation and by crossing them with already cultivated varieties.

I have said that the rejuvenescence of a scion by means of a “graft” is equivalent to a partial restoration of symbiotics, and like an infusion of “new blood” which yet in a manner of speaking is “old blood” (the blood of an unspoiled blood-relation with more vitality, and more likeness of composition with that of the common progenitor), and we may thus anticipate with some degree of confidence the conclusion, subsequently to be reached, that desirable “full-bloodedness” does not, as some artificial writers assume, arise from and require sanguinary methods of feeding (in-feeding), but that

its origin and efficiency are due to appropriate symbiotic activities.

On Mr. Pickering's showing, the welfare of a tree in general depends on its ability to send out new roots from the stem, in order that these roots may come into as close as possible contact with the soil. It is significant in this connection that as a result of protracted experiments Mr. Pickering and others, in considering the best treatment of trees, came to conclusions which are calculated to confirm, also in other particulars, the view here taken of the building up of capital and of Bio-Dynamics in general.

Secondly, we may turn to the effects of *pruning*. It has been recently established as a fundamental principle, that "the less pruning there is, the more will a tree grow, and the more fruit will it bear."

It is true that this does not altogether remove the necessity of pruning for purposes of shape, but the discovery that continued annual pruning is harmful to the welfare of the tree, runs counter to many of the identical prejudices with which I have throughout to contend in promulgating my bio-economic theory.

While pruning is justified and, indeed, necessary on horticultural grounds, men are apt to go on to infer that mutilation itself is advantageous on the same line of thought which advocates hunger and hardships as spurs of industry. Used to thoughtless abuse of bountiful nature, man has too long been satisfied to rely immoderately on the rough principle that the more you stimulate an organism by pain and mutilation, the more you call forth efforts on its part to make up in other directions. But although endowments are vast and ancient, there is a limit to which they can be drawn upon. Regeneration and reaction to destructive action have their limits, and stimulation and mutilation largely fail of their usual effect where a due compromise between racial expenditure and bio-economic contribution has already been established by a species.

A similar prejudice exists in the matter of medicines, for many of us secretly think that the nastier and more drastic a dose is, the more likely it is to be efficacious, and a German proverb exists among the peasantry that the more a manure stinks the better it is. "Was gut stinkt, das gut düngt."

Continuous inconsiderate annual pruning of the branches thus causes an exhaustion of vital powers. The same is true of root-pruning. "In this the roots are unearthed and cut back, with the view of increasing the fruitfulness of the tree. The check which such an operation gives to the growth is very severe, and if carried to excess will kill the tree entirely." We saw that in grafting, the stock, as the superior retainer of symbiotics, had a far greater value than Mr. Pickering's observations would lead a casual reader to suppose. Not only as a purveyor of essential nutrition, but also by determining more particularly the general habit of spreading does the stock proclaim the superiority of its symbiotics. When we now find that great damage is done by indiscriminate pruning of branches and roots, we see again how great the influence of the stock's symbiotics must have been—determinants as they are of the very habits of spreading in the grafted tree.

We are told that to what extent pruning should be carried, and for how long it should be continued, must depend on the *habit* of the tree; and, further, that a balance between roots and branches is desirable. This confirms what I have said before concerning the influence of habits upon the dynamics of growth generally. We can restrain a tree from bad habits, and we are also able to restore a lost balance—those are the benefits which happily we can confer on our vegetable benefactors. But in order to do this well, we must understand the true needs of the plant and principally how it came by its vitality and status—its high symbiotic position in the world of life—in virtue of positive ancestral dynamics (symbiotics).

I have stated above that the integration of physiological capital on the part of a species as well as the arrival of genuine "full-bloodedness," depended on adequate initial function—

on adequate symbiotics—and, in the case of the tree in particular, on its “work” of drawing efficiently on the soil. In that sense it is true indeed that: “The flower must drink the nature of the soil before it can put forth its blossoming.” So long as such ancestral dynamics continue, the tree retains its main character, its vitality, its definite and co-operative vascular arrangements, its power to reproduce from seeds, ability to send out new roots from its stem, and its vital symbiotic correspondences; characters and assets which are in the course of disintegration in the case of the grafted tree which does not draw directly on the soil. That the provision of intimacy of contact between soil and root system, in which I see a means of restoring symbiotics, is of surpassing importance, may now be gleaned from Mr. Pickering’s remarks on the need of particular care of such contact in transplanting trees.

Two other conclusions may also be drawn from what has been mentioned, namely, that it can make little or no difference to the future welfare of the tree whether the ends of the old roots are trimmed or left jagged and torn, as they are when removed from the nursery, nor whether these roots are carefully spread out in the ground instead of being huddled into the hole prepared for them, for it is the new rootlets which are to be formed, and not the old ones on which the future life of the tree depends. Both these conclusions have been verified by actual experiment. Even when the roots were twisted and tied together in a bundle, the tree did just as well as when they were spread out in the orthodox fashion.

It is thus seen that all these practices which are supposed to be essential to the proper planting of a tree are really immaterial, and, in fact, that the violation of them within certain limits is beneficial. But the benefit was not sufficient to explain certain results which we obtained, and which puzzled us for many years. We had made a plantation in which, by way of demonstration, the trees had been planted in violation of all the accepted canons, and we expected that these trees would afford an awful lesson to the careless planter. But instead of that, they flourished rather better than their carefully planted neighbours. The results were naturally set aside as accidental, and a repetition, and subsequently many repetitions, were made, but the roughly-planted trees refused to behave badly and flourished so much more than their neighbours that they often showed two or three times

more growth than these did. The principal cause of this was eventually traced to the fact that *the soil round these trees had been heavily rammed* at the planting instead of being shaken over the roots and merely pressed down. When we consider that the welfare of the transplanted tree depends on its sending out new rootlets from the old roots, it is evident that anything which brings *the soil into intimate contact with these roots* will be beneficial, and ramming the soil down, especially if it is in a wet condition at the time, will do this more effectually than could ever be done by the gentler method of planting. These somewhat surprising results, therefore, receive a simple explanation, and it is easy to satisfy ourselves, by lifting the trees at the end of a year, that the rammed trees have actually formed more new roots than those carefully planted. (*Italics mine.*)

The direct draft of nutrition from the soil, *i.e.*, the mineral world, which is here seen to be vitally important, is what I call "cross-feeding" for the plant, and is parallel to the symbiotic draft by animals on the vegetable world.

So much in biological interpretation, in my opinion, depends on this view of "cross-feeding" and its bio-economic correlations, that it is worth while to show from a few other instances how much is owing to this principle, and why it is indispensable to the evolution of life.

In *Knowledge* (May, 1914) reference is made to M. Skene's investigation (New Phytologist, 1914) of some members of the remarkable group of *Schizomycetes*, included under the name of "sulphur bacteria."

It was found that: "In mixed cultures, *Amæbacter* (and probably also *Lamprocytis*) *thrives best in a mineral solution* containing ammonium sulphate as a source of nitrogen, and with chalk as a neutralising agent. All the *organic sources of nitrogen* and carbon which were investigated *proved to be without* favourable influence on the growth of the bacteria; indeed, as a rule *they tend to inhibit development.*" (*Italics mine.*) And, further, that: "Growth takes place only in light." . . . "The purple sulphur bacteria require free oxygen which is probably supplied *in nature by associated green organisms.*"

These bacteria, then, are typical cross-feeders and as such

thrive well. Associated with a proper habit of feeding we find the power of photosynthesis and—depending on both—the capacity of carrying on genuine symbiosis with higher (green) plants. The oxygen required for their own industrial purposes they are able to purchase from the symbiotic plants, and, having got it, they use it to oxidise sulphur or one of its unoxidised compounds, producing in some cases sulphur, and in others sulphuric acid. They are thus of agricultural use in a similar way to the nitrogen-fixing bacteria in the soil and in symbiosis with the plant, and this in so far as they are mainly cross-feeders.

The same inferences may be drawn from examples taken again from the genus *Chlamydomonas*, showing us at the same time how “variations” arise according to differences of feeding habits, and how symbiogenesis depends on appropriate nutritive conditions.

Thus Prof. Bretland Farmer in his little book on *Plant Life*, page 33, reports that in the Alga, *Chlamydomonas*, the formation of colonies, *i.e.*, the first step towards complexity of organisation, depends upon the supply of “appropriate nutritive media,” and it is for my purpose important to note that these are *mineral salts*, *i.e.*, the proper food of the plant, thus again emphasizing the value of cross-feeding as a vital factor of development.

Neither the quantitative nor the qualitative distinctions that I have so far drawn have as yet been recognised in Biology. Yet that a beginning is at last being made is evident also from Prof. Klebs’s protest against the constantly repeated expression “good or favourable nourishment,” which, he cannot help realising, is both “vague” and “misleading,” seeing that circumstances favourable to growth differ from those which promote reproduction. He expresses the view that “for the *production of every form there are certain favourable conditions of nourishment*, which may be defined for every species,” which, in my view, means that nutritive specialisation varies with bio-economic specialisation.

The first necessity of organisation and colony-formation is work and mutual surplus of work on the part of the units, and this requires a kind of nutrition which is both qualitatively adequate and quantitatively unobstructive.

We have seen that in-feeding leads to a loss of photosynthesis and concurrently results in obstructive surfeit (impedimenta). This mode of nutrition, therefore, is not associated with "appropriate nutritive media," with appropriate physiological currency. It does not lead to progressive symbiosis. It means disruption. That we have in our bio-economic theory indeed a universal principle, which shows other differences to be more apparent than real, and that our investigators from totally different considerations are driven to similar inferences (though expressed in a different terminology), is strikingly evident from Prof. Bretland Farmer's opening remark.

A general survey of the biological field shows that the evolution of the higher from the lower forms of life, strictly depends on the due discharge of the two great functions of *nutrition* and reproduction. (*Italics mine.*)

The same botanist also shows by an experiment how plantagens may be forced asunder from a previous symbiosis by improper (surfeiting) nutrition.

If the plant (*Cladophora* sp., marine species) be placed in sea-water to which a strong salt solution is slowly added (up to about 12·5 per cent.), the protoplasm of each of the cells contracts away from the walls, and forms an ellipsoidal mass within each cell cavity. The protoplasts then surround themselves with new walls. After allowing them to remain in this condition for about four days the strong salt solution is gradually replaced by sea-water. The ellipsoidal cells swell out until they approximately fill the space they previously occupied within the old membrane. But the disunion has obliterated the mutual relationship formerly existing between cell and cell. Each one proceeds to develop without any reference to the rest, and puts out a basal attaching organ below, which usually penetrates the adjacent cell cavity. Later on the cell also proceeds to grow in the apical direction. Thus the individual cells of the filamentous colony have been, in this experiment, released from the influence which bound them together into an organism, and have recovered complete autonomy and individuality. This has

occurred as the result of sundering the protoplasts from all communication with one another for the period of time during which they remained contracted in the strong salt solution.

A "strong" salt solution means surfeit and poison, and is known generally to have a retarding effect upon plant physiology, as we have seen such causes to have upon the developments of symbiosis and of sex, *pari passu* with retarding evolutionary—bio-economic and bio-social—effects.

The protoplasm contracts and turns "unsocial" in the presence of food unsuitable for the proper discharge of its bio-economic function. It seeks isolation rather than union. The disunion in a few days obliterates the mutual relationship existing between cell and cell, which revert to a more primitive condition. We thus see that whilst a suitable nutrition provides the influence under which a number of individual cells may bind themselves together into a colony, obversely an unsuitable nutritive stimulation has the effect of sundering the protoplasts from all communication with one another. The bonds of society (symbiosis) are snapped asunder, as Carlyle says in reference to the anarchy prevailing in France during the great Revolution. It is, indeed, true that the co-ordination (co-operation!) to form an organism is bound up with mutual interchange of material (trade!), but it is a definite contribution that is wanted from every individual if a definite union is to result. Though there may be slight differences of character, there must be sufficient symbiotic influence affecting the character of the individuals in a manner sufficiently uniform and sympathetic to aid them towards the combination into a greater and similarly sympathetic (symbiotic) organism. *This common bond of co-operativeness is provided by such a nutrition as lends itself most to co-operative purposes* generally, which is most compatible with domestic and bio-economic efficiency, viz., symbiotic nutrition.

The essential contrast between two modes of life has thus again been very distinctly brought home to us. Again we reach the indispensable conclusion that it is the *symbiotic mode alone*

—*the path of work, serviceableness, and reciprocity*—that provides the proper stimulations for the progressive evolution of life.

The opposite method, as exemplified artificially by the cutting or scion, and in nature by epiphytes, scavengers, carnivores, and parasites, is a one-sided method depending on mutual plunder, on exhaustive stimulation, on abuse of power by exploitation. It represents the path “that leadeth to (biological) destruction.”

Another passage of Mr. Pickering’s valuable paper is worth quoting here as bearing on the important subject of “love-foods,” their derivation and mode of production and on their symbiogenetic significance.

When a grain of pollen, either of the same or another flower, enters the central tube or pistil, fertilisation occurs, and a seed or pip begins to form near the base of the pistil. As it develops, the woody substance surrounding it, which is really a portion of the stalk of the tree, gradually swells to a remarkable extent and eventually forms the fleshy or edible portion of the fruit. We commonly call it the fruit, but it is only a metamorphosed portion of the mother tree: the real fruit of the tree, the progeny of male and female elements, is the pip.

The tree is ready to give of itself—particularly so after having (symbiotically) received the stimulus of fertilisation—*i.e.*, to elaborate an exchange product for export against service.

This stimulus is particularly valuable if it is one of cross-fertilisation, as Darwin has demonstrated by his classical experiments. It is here where I consider Darwin greatest and most worth following up, whilst, strangely, many of his followers who swear by the master’s words on debatable points think him most open to criticism. Darwin declared:—

Yet if a little pollen were carried, at first occasionally and then habitually, by the pollen-devouring insects from flower to flower, and a cross thus effected, although nine-tenths of the pollen were destroyed it might still be a great gain to the plant to be thus robbed.

That the stimulus in cross-fertilisation is very frequently and very reliably conveyed by animal agency is well known,

though not the extent to which this occurs in nature; the extent to which the plant can "metamorphose" portions of itself, without harm or loss to itself, into "remuneration" of the cross-fertilising animal, and to which this arrangement has come to be (what I might now term) a symbiogenetic fixture—an indispensable organic asset worth many an organ to both plants and animals concerned.

From the above quotation from Darwin we can almost see graphically how symbiotics gradually arose in nature and how their increasing perfection and efficiency resulted in increasing security and reliability of life, rendering anti-symbiotic (anti-social) adaptations and so-called "over-specialisations" correspondingly unnecessary.

I have, no doubt, treated the case of both symbiosis and of "love-foods" too sparingly in my little book on *Evolution by Co-operation*.

Sir Francis Darwin, to whom I took the liberty of sending a copy of that book, kindly pointed out to me that it fails to convince on these matters. I here reproduce some of the correspondence, because it sets forth in terse form the difference of two specific points of view—the general outlook now reigning in Biology, and the one I wish to substitute for it.

Sir Francis states:—

Organisms have to fit themselves to their environment, and since their environment is largely made up of other organisms a *modus vivendi* is arrived at, but I fail to see any gain in clearness in calling it co-operation—indeed, I think it obscures the problem. Nor can I see the point of cross-feeding and in-feeding; you seem to believe that there is some essential and striking difference between plants and animals considered as food—which I do not understand. How do you deal with the case of a herbivorous animal such as a cow, whose calf is fed *in utero* by the closest of in-feeding? Or the case of a germinating acorn in which the young plant is at first an in-feeder?

In my reply I pointed out:—

I use the word co-operation as equivalent to symbiosis, but as illustrating the similarity of this process in biology to that of economics, and I try to show that the *modus vivendi* arrived at is far more stable

and profitable when it is really co-operative and not merely competitive, resting on increasing mutual aid instead of on mutual plunder. Species as well as individuals co-operate just as classes and nations co-operate in international exchange as well as individuals in a town or a factory and always with immense mutual advantage. . . . Sexual reproduction is, I hold, an instance of this successful co-operation of specially differentiated individuals and, on a broader view still, I submit that the organic world has been enormously advanced by the co-operation of the specially differentiated plant and animal. But it must be co-operation in which both gain, and not depredation in which one side, at any rate, temporarily, loses.

You refer to adaptation. I do not deny adaptation. I do not mean that every adaptation comes under the head of co-operation. But I am trying to show where it does and where it does not, in the same way as I am trying to show where physiology ceases and where pathology begins.

As regards cross-feeding compared to in-feeding, besides the fact that in-feeding and especially parasitism, its extreme form, implies depredation and not co-operation, in-feeding also involves the absorption of the waste products and poisons in the organism preyed upon, and this, with the usual concomitant over-stimulation of some functions (e.g., reproduction) and atrophy of others from disuse, tends to disease, degradation, and extinction. My generalisation is that Nature abhors *perpetual* in-feeding. That in-feeding is quite possible and, for a time, may even have its use, I deny no more than Darwin denied that "in-breeding" is conceivably sometimes of use. Other things equal, however, cross-feeding is superior.

As regards the young in-feeding while *in utero*, I do not regard this as in-feeding for two reasons: first, that it represents a process of self-development, i.e., discontinuous growth, and is merely an incomplete fission during which the young depends as much on the maternal digestive system as the mother's own organs and, secondly, after birth the offspring is fed not on flesh, i.e., not on an indiscriminate carnivorous method but on a specially prepared "love-food" eminently suitable, non-stimulating, and not containing waste products or poison. (Cases of embryonic gluttony and consequent reproductive nemesis represent the penalty for the acquisition by the species of wasteful feeding habits.) So with the adult cross-feeding. The grain of cereals and pollen of flowers are specially prepared products serviceable first for home use and also available for co-operation with the animal world, as special surplus manufactures are available for export trade to the advantage of all concerned—services being rendered in exchange, as for instance distribution of seed, the saving of pollen as against wind fertilisation, etc. In the apple and plum pulp a special food is manufactured for export alone in return for services.

That this co-operation is unconscious is only parallel to the cognate process in the economic world where the individual trader or manufacturer hardly realises that he is co-operating in equating the balance of trade and serving his fellows as well as himself. And I regard a highly evolved species, with its increased power of producing physiological values and its inherited qualities and powers as equivalent to a developed nation with its educated faculties and accumulated capital.*

Fertilisation is thus attended by manifold services and counter-services—in domestic and biological symbiosis—and the tree's share of service consists in the manufacture (partly for export) of pulp (amongst other things)—the woody substance surrounding the pip (which, according to Mr. Pickering, is really a portion of the stalk of the tree) gradually swelling to a remarkable extent, and eventually forming the fleshy or edible portion of the fruit.

The stimulus that has brought new life has also brought new activity with fresh services. The tree is not "devoured," nor even robbed or deprived of its chances of producing offspring commensurate with its biological status. Fertilisation is here seen to be in the service of general productiveness, and, it may yet turn out, that sex itself is but a call towards an ever-increasing symbiosis.

The conception of a highly evolved species with its inherited qualities and powers as equivalent to a developed nation with its educated faculties and accumulated capital, closely connected as it is with the conception of "love-foods," opens up the problem of heredity.

* I notice from Prof. A. Dendy's address, as president of the Zoological Section, British Association (Melbourne, 1914), that he favours the parallels with Political Economy which I have been emphasizing for some little time. He speaks of the progressive accumulation of potential energy (or capital) in the germ-cells of successive generations of animals—a certain amount of protoplasm loaded with potential energy forming the main part of an inheritance—and of the sometime "inherited incapacity for progress"—being the same phenomenon amongst animals as amongst men. Although he thinks that it is quite impossible for us to say to what that incapacity is due, he states that "the contrast between man and nature is purely arbitrary; man is himself a living organism and all the improvements that he effects in his own conditions are parts of the progress of evolution in his particular case." He answers the great question, "Why do organisms progress at all, instead of remaining stationary from generation to generation?" by suggesting that the power of profiting by experience lies at the root of the problem. It only remains thus to be demonstrated more explicitly, how profits accrue, how they are exchanged, distributed, mutualized, and increased, and how this (symbiotic) process spreads and in the spreading antagonizes stagnancy.

Modern biology looks upon the foetus as a living part of the mother, and, hence, we may regard the species as a continuous whole. This really should do away with the imputation of parasitism in the case of mammalian reproduction—as though the temporary (sacrificial) attachment in this case were on a par with the worst instances of attached (*i.e.*, obligate) parasitism!

With such narrow views it is indeed difficult to approach the problem of “heredity,” *which is nothing if not a problem of values.*

In considering a species or a branch and its place and value in the world of life (its heredity), we must ask ourselves what is its total bio-economic output of work and of values.

The branch is composed of symbiotics and likewise of anti-biotics.

As Prof. Bateson has it:—

We animals live not only by virtue of, but also in spite of, what we are.

It is the resultant of the interplay of symbiotics and anti-biotics which determines the present value. What a species or a branch is capable of projecting of such a resultant into its progeny at any moment, that is its heredity. The first question we have to ask ourselves is whether on the whole symbiotics or anti-biotics predominate?

CHAPTER III.

GENETICS.

When we approach the problem of heredity from the experimental side we get very strong evidence of the existence in the germ-plasm of definite material substances associated with the inheritance of special characters. . . .

From our point of view the interesting thing is the possibility that arises through the sexual progress of the permutation and combination of different factors derived from different lines of descent. . . .

One species does not arise from another species, but from certain individuals in that species, and when all the individuals become so specialised as to lose their power of adaptation, then changes in the environment may result in the extinction of that line.—PROF. A. DENDY.

Those who would proclaim that whatever is is right will be wise henceforth to base this faith frankly on the impregnable rock of superstition and to abstain from direct appeals to natural fact.—Prof. W. Bateson.

Dans ses écrits un sage Italien

Dit que le mieux est l'ennemi du bien.

—VOLTAIRE.

In the preceding pages we have already anticipated that the problem of Heredity is essentially one of values. Expressed in terms of Bio-Dynamics, it was stated that those endowments which a species was capable of transmitting to its progeny as a resultant of its symbiotics and anti-biotics represented its heredity, *i.e.*, that which forms its endowment, but it is always essential to determine whether symbiotics or anti-biotics predominate, so as to arrive at some criterion as to the ultimate effect of such heredity.

The term "endowment" is widely used in Biology, without care as to the origin of the endowment, by those writers whose theories of evolution lead them to beg the question of such origin and of the positive

factors of evolution. The word, however, contains the tacit implication that the building up of heritable physiological "funds" is of a similar nature to the building up of "capital" in commerce and industries, or the wealth bestowed in the endowment of persons or institutions. It is not every race of the past that has been able to establish adequate "funds" for a sufficient biological endowment of progeny or to replenish its patrimony of ancestral dynamics as fast as it was drawn upon. Here, again, the analogy between organic and human failures is very close, and strikingly suggests a universal principle.

Many animals have become extinct without leaving modified blood-descendants. Thus, for instance, the megatherium and other allied monsters, as Darwin tells us in the *Origin of Species*, have become wholly extinct and left no progeny. I have explained this failure as due to loss of symbiotics, and there is plentiful evidence to show that the similar failure of many ancient and comparatively recent races of man is due to the same cause. It is clear that the laws laid down by the great law-givers of old: Moses, Buddha, Zoroaster, Pythagoras, Plato, Jesus, St. Paul, Mohammed, etc., by enjoining mutual forbearance, restraint and bodily and social hygiene, in reality all aimed in various degrees at the maintenance or restoration of physiological and symbiogenetic integrity.

In Nature as in human society it is true that many are called but few are chosen, but to be chosen is a matter of qualification and *not* of accident or Providence, as Addison and others seem to have thought:—

If Providence shows itself even in the blemishes of these creatures, how much more does it discover itself in their several endowments, according to the condition in which they are posted.

That there had to be adequate basic dynamics, if certain primordial individuals or species were to be charged with sufficient powers to become the progenitors of long future lines

of successful branches, must be considered as inherently probable. In the following pages we shall see further evidence to that effect.

Speaking of animal classification in his work, *Essays on Evolution*, Prof. E. B. Poulton tells us that the higher subgrades, the *Cœlomata* (animals with a cœlom or body-cavity surrounding the digestive tract) include nine *Phyla*, and he emphasises the fact of an *immense evolutionary history* which must have been passed through *before the ancestor* of one of the higher of these nine *Phyla* came into being. (Italics mine.)

He also states:—

When we have decided the question of the other *Cœlomate Phylum* or *Phyla* to which the vertebrate ancestor belonged, there remains, of course, the history of that *Phylum* or those *Phyla* earlier than the point at which the vertebrates diverged, right back to the origin of the *Cœlomata*.

The evolution of the ancestor of each of the higher *Phyla* probably occupied a very long period, perhaps as long as that required for the evolution which subsequently occurred within the *Phylum*.

Prof. Poulton adds the further reflection:—

It is, of course, a perfectly trite and obvious conclusion, but none the less one to be wondered at, that the force of heredity should thus far outlast the ebb and flow of terrestrial change throughout the vast period over which the geologist is our guide.

There is, indeed, plentiful cause for wonderment at this astounding success of a physiological force in outlasting the ages. The force itself, however, seems to be rather inadequately described as the "force of heredity," although it works by "heredity." In view of what has been said already it seems more adequate to speak instead of positive ancestral dynamics (symbiotics) persisting in efficacy and hereditary potency, precisely in so far as they are not abused or wasted by inferior or retrograde recent developments, such as are, broadly speaking, induced by cessation of "work."

Instead of wondering at the mysteries of "heredity," let us consider for a moment the bio-dynamic implications

involved by the above passages. We may say that the evolution of the *Cœlomata* in order to perfect an indispensable physiological and psychological endowment required long lines of ancestry, and, as time alone can do nothing, we may draw the further inference that the ancestral activities must have been mainly of a nature to produce the necessary symbiotics.

"From a causal-mechanical point of view," says Klebs, "it is not *a priori* conceivable that a species can ever become changed into another so long as external conditions remain constant," and an Italian proverb says perhaps more aptly still: "Il lungo giorno nò, ma il cuor fa l'opera."

If we add the bio-economic to this causal-mechanical point of view, we may state with more precision that no species can ever be changed progressively except symbiogenetically, and that every retrogressive change has its cause primarily in lapse of symbiogenesis.

It was one of the *Cœlomata*'s conditions of existence and of subsequent success to have had bequeathed to them an ancestrally acquired physiological capital of the most ample and auspicious kind.

To what an extent could the nine *Phyla* rely upon the ancestral dynamics bequeathed to them by the common vertebrate ancestor of the *Cœlomata* group? To what extent did any of them subsequently abuse their inheritance? These are questions which we might ask, and which it might be profitable to go into some day in a systematic manner. Here we are only concerned with the general principle, and to a certain extent the questions raised answer themselves by the explanations of the causes of biological success or failure already given in the previous chapter.

We have seen that Prof. Poulton felt constrained to express wonderment at the fact of the "force of heredity" outlasting vast periods of geological time. We argued that time alone can do nothing, and we demurred to the use of the term "hereditary force" as too vague. We concluded that to evolve a satisfactory progenitor of subsequent successful

phyla of animals required a very gradual symbiogenesis with its high physiological values accumulated by inheritance, and in this connection it is obviously of great importance to consider a little more exactly what the modern teaching about heredity is.

On consulting Prof. A. J. Thomson's volume on the subject, we learn that Heredity is:—

(a) "A sort of maze in which Science loses itself."
(Balzac.)

(b) Determines the individual life.

(c) The genetic relation between successive generations.

(d) An organism's genetic relation to its forbears.

(e) A condition of all organic evolution.

The same writer also tells us: "What the living creature *is or has to start with in virtue of its hereditary* relation; what it does in the course of its activity; what surrounding influences play upon it—these are the three determining factors of life."

From the above we do not get much further light than we have gathered in previous pages to the effect that what a particular generation has available in ancestral and more recently acquired dynamics, together with their corresponding physiological or pathological, psychological and bio-economic correspondences, ready to be projected into the next generation, represents its hereditary endowment. "Heredity is a condition of all organic evolution," because it is a record and result of racially accumulated values, and all organic evolution is primarily based on the production of such values.

The true genetic relation between successive generations involves values quite as much as it involves blood-relationship, and the bio-economic integrity to be handed on is as important as physiological integrity. Everything in evolution, as we have seen, turns round the production, utilisation, and adequate accumulation, preservation and distribution of organic values. Whilst one generation of organisms is completing its life cycle of activities, whilst it is having its share

in the use of organic values, it is made in turn by the force of organic solidarity to preserve old and, where feasible, to mature and to accumulate additional values. We have seen that really the more indispensable specific values are to the welfare of the organic world, the more widely will the persistence of the particular species which create and accumulate such values be cherished; just as inversely, in the opposite case, it will be more or less condemned to gradual elimination.

The same applies in heredity. It is a condition of continuance and of progress, provided the bio-economic usefulness of a species be such as to justify a widespread concern in its perpetuation. And thus it is, in Prof. Thomson's words, that "there could not have been any evolution in the animate world without heredity as one of its conditions." Without the power of storing the results of labour and of accumulation of values there could have been no evolution. Continuance, *per se*, is no criterion of normal or progressive evolution, because obviously, and as we have seen, it is frequently attended by degeneration and decline. The success of organic life is not due more to heredity than to reproduction. It is due to symbiogenesis, which means mutual enhancement by continuous mutual effort; that is, the productive is as important as the reproductive factor. Heredity further represents the demand of at least a modicum of nobility on the part of every organism.

Of Prof. Thomson's definitions, (b) seems to indicate no more than that race is in general stronger than the individual. To what an extent the individual life is determined by "heredity" (race) remains, however, to be seen in each case. Obviously there are many and varying degrees of determination. Some individuals are more determined than others not to be predominately "determined" by heredity (race) and strike out new lines of their own. Others have the good fortune or good sense to break away from morbid tendencies engendered by their forbears, making a good recovery, and at the same time making a bid for further evolution. The case

is well put by Samuel Butler (*Luck or Cunning*), speaking of the views of Erasmus Darwin and Lamarck:—

They held that some organisms show more ready wit and *savoir faire* than others; that some give more proofs of genius and have more frequent happy thoughts than others, and that some have even gone through waters of misery which they have used as wells. The sheet anchor both of Erasmus Darwin and Lamarck is in good sense and thrift; still they are aware that money has been sometimes made by “striking oil” and ere now been transmitted to descendants in spite of the haphazard way in which it was originally acquired. No speculation, no commerce; “nothing venture, nothing have” is as true for the development of organic wealth as for that of any other kind, and neither Erasmus Darwin nor Lamarck hesitated about admitting that highly picturesque and romantic incidents of developmental venture do from time to time occur in the race-histories even of the dullest and most dead-level organisms under the name of “sports”; but they would hold that even these occur most often and most happily to those that have persevered in well-doing for some generations.

How the favour of new though apparently adverse circumstances may in reality induce recoveries through the forced adoption of new habits, I have instanced in my *Evolution by Co-operation* by the case of *Dendrocygna Autumnalis*. This duck when compelled by circumstances to feed upon seeds and grain, instead of animal life, becomes so relatively light and active that “it can alight on a stalk of growing corn with the ease of a blackbird, and it is quite at home among the lofty trees where it makes its nest.”

In a similar way the children of Israel were led away from the fleshpots of Egypt into the desert, there to feed on “manna” and thus to rejuvenate the race. No organism, of course, is stronger than race. None can deny race. Everyone has to bear the burden of race as well as inherit its advantages. Racial “honour,” however, may be measured by bio-economic standards, which involve loyalty to the cosmos and its order. With these qualifications we will accept Prof. Thomson’s further statement that “heredity is no entity, no force, no principle, but a convenient term for the genetic relation between successive generations, and inheritance includes all

that the organism is or has to start with in virtue of its hereditary relations."

How do we now account for the fact emphasized by Prof. Poulton of the extreme slowness of progressive evolution in early ancestral types, compared with the rate of progress in more recent times? Prof. Poulton states: "Undoubtedly a study of all the available evidence points to the conclusion that in the lower grades, sub-grades, and *Phyla* of the animal kingdom, evolution has been extremely slow as compared with that in the higher. We do not know the reason."

We shall say that in those early days the most powerful factors of evolution, *i.e.*, reciprocal stimulation, reciprocal differentiation—domestic and biological symbiosis—were but very slightly developed, and that a more rapid rate of progress depended on increasing efficiency of these factors which came about with an increasing complexity of the web of life, and which required and implied increased co-operation, and especially symbiogenesis.

The increase of co-operative biological interaction, as in the case of international human relations and amenities, proceeded gradually and, at first, slowly. The quickening came later with the spread of higher values and of increasing security of life.

I have already alluded to Darwin's emphasis of the fact that, "after long intervals of time, the productions of the world appear to have changed simultaneously," as pointing to bio-economic interaction of the kind set forth in the preceding pages. What other cause but that of organic and bio-economic solidarity could have produced inter-connected simultaneous effects of such magnitude and universality, second only to the effects of the force of gravitation?

Natural Selection? But it is supposed to be an agency working for the good of every individual under its *particular* conditions, *i.e.*, to be a principle of mere expediency. How could it have produced such *simultaneous* changes? It "operates" by mutual plunder and death irrespective of the

common bond, and though it may be said, of course, that death makes all organisms alike, this same agency cannot very well change all survivors simultaneously. As Butler puts it in his own case against Natural Selection:—

Do animals and plants grow into conformity with their surroundings because they and their fathers and mothers take pains, or because their uncles and aunts go away? For the survival of the fittest is only the non-survival or going away of the unfittest—in whose direct line the race is not continued, and who are, therefore, only uncles and aunts of the survivors. I can quite understand its being a good thing for any race that its uncles and aunts should go away, but I do not believe the accumulation of lucky accidents could result in an eye, no matter how many uncles and aunts may have gone away during how many generations.

Let us take the case of organisms specially “adapted” (extremely determined) to a particular “environment”—like parasites. Though they be thus “naturally selected,” by what logic can we presume them to have changed simultaneously with, say, organisms that all the time have remained strenuous? Neither their mode of change nor rate of change can bear the slightest resemblance to those operative amongst the strenuous organisms. The “heredities” are totally different because the directions of evolution are totally different. An organism living by plunder instead of mutual aid is able to “progress” along its own lines (which are those of the inclined plane) and often rapidly. In so doing it cannot very well be said to make a change simultaneous (so far as regards any inter-connected series) with that of slow advancing strenuous organisms. Organisms living by mutual support develop quite differently, for here the correspondences with the external world are many and profound, and every change must be a correlated change. The complexity of their correspondences by way of reaction implies a complexity of organisation, and there again, as Spencer has shown, every change of function must be long continued and of a permanent nature to stamp a permanent change on so complex an organisation. On the other hand, and this is what Spencer omits,

such an organism has earned for itself and reaps a harvest of needed and fructifying services and stimulations, a persistence of force accruing from the complex interactions and integrations of the web of life. Though rate of progress among the strenuous types be thus relatively slow, it is sure and always results in rise of status in the end, and it is these types that are seen to be growing still upwards, whilst degenerates and "hasty climbers" have, in many cases, reached an untimely end. Man is one of the slowest breeders among animals, but his "breeds" in the end have remained superior and are the most progressive to boot. Surely this is connected with values! In this sense it is true also that *Natura non facit saltum*.

Darwin's references to the simultaneous changes of organisms is true in the purely chronological sense so long as we make the necessary qualitative distinctions. The grains changed simultaneously as other grains changed, and the chaff as the chaff, but grain and chaff changed in different directions, and with widely different ultimate results. It is curious in this connection to note that Darwin clearly perceived that terrestrial organisms, because of the more complex (partly economic) relations of their organic and inorganic conditions of life, enjoy a quicker rate of change than aquatic organisms, which is another adumbration of the bio-economic view. Failing a recognition of the bio-economic and symbiogenetic view, we find him disconsolately exclaiming in a letter to Hooker: "The rapid development, so far as we can judge, of all the higher plants within recent geological times is an abominable mystery."

It is now manifest that the data generally adduced as regards geological time required by the evolutionary process, in the absence of a proper biological analysis, must remain highly problematical. Evidence thereof we have in a recent article by Mr. H. S. Shelton in *Science Progress*, October, 1913. He states:—"Vague as are the data of the geologist, those of the biologist are still more uncertain," and he demurs to Prof. Poulton's inference that pre-Cambrian evolution must have

occupied a time vastly greater than that of which we have a record, for which view, he says, we have no more than an antecedent probability. He suggests that habits may have something to do with relative slowness or quickness of evolution. The species of the pre-Cambrian era had perhaps not yet acquired the "lime-habit," *i.e.*, as I would say, surfeiting nutritional habits. If so, they could accomplish more evolution in comparatively shorter time than subsequent assemblages of animals which, in connection with their surfeiting habits, had made the fatal adaptation of forming heavy carapaces; and we are not warranted in making the slowness of evolution during the latter phase a measure of the time it must have taken evolution to raise the unencumbered antecedent species. We may be dealing with different orders of facts.

"It will be generally admitted that the formation of exterior protective lime coatings is likely to render further developments both difficult and unnecessary."

"The one notable example of the higher development of such invertebrate forms, the *Cephalopods*, has only taken place as and when the protective coating has obsolesced."

In the course of his argument, showing that there is frequently little validity in the geological arguments as used by biologists, the same writer touches on the problems of "use-inheritance" and Mendelian laws of inheritance. He states that as regards the higher animals it is now generally recognised that the mutual infertility of nearly allied species is a test of species difference, and, further, "Physiological infertility is evidently not correlated with accidental differences in shape, colour or form, but connotes an essential, deep-seated organic change."

Again, we thus see how everything points to a deep-seated qualitative change, *i.e.*, to a change of bio-economic (and associated physiological and bio-chemical) value as a necessary preliminary to or concurrently with the formation of new species.

"It seems probable, therefore," continues Mr. Shelton, "that this mutual infertility may not be obtainable by

artificial breeding, but that it may be a natural process, which for its accomplishment requires prolonged time."

That ample time is, of course, necessary for the establishment of high bio-economic status and specialisation is evident on my theory, which demands a combined and protracted nutritional and sexual gestation, a building up of values by steady and continuous accumulation, and the gradual establishment of an ever-widening circle of co-operation and of exchange of values—in short, a protracted symbiogenesis in a complex web of life. But that the length of time taken in the accomplishment of such desirable results is not fairly to be compared with that of artificial, non-symbiotic or even anti-symbiotic or pathogenetic developments is also evident.

"Let us look at Mendelian inheritance," suggests Mr. Shelton, "not as the normal form of inheritance, but as a modified form of mutual infertility. Mendelian inheritance is the characteristic of stocks that do not truly blend, and the different varieties emerge from the process of inter-crossing practically unchanged. This clearly tends to fix the types of the crossing varieties."

This is an interesting view which is well worth considering, and provides a convenient introduction to an inquiry from the symbiogenetic point of view into the subject of Mendelian inheritance now so prominently before the scientific world.

We have seen the need of wholesome diversification, *i.e.*, of progressive bio-economic specialisation. It is inherently probable that there must be in nature manifold provisions for rendering such wholesome diversification secure from the swamping effects of inferior physiological strains (from inferior physiological currency); in the same way as we find especially valuable parts of the body, the brain and the germ-substance, for instance, specially isolated and protected in many ways. It may be, as Mr. Shelton suggests, that usually when Mendelian segregation appears, this is an indication that the previous crossing of the respective pair of "allelomorph"

characters was somehow not relished by nature, and therefore failed to yield a satisfactory and permanent blend, *i.e.*, that we have in such an instance behaviour not far removed from that usually termed mutual infertility. If this be so, segregation may be regarded as a kind of protection of desirable (blended) inheritance, which may again proceed unobstructed as soon as undesirable foreign strains are eliminated *in toto*. I should say that the partial mutual infertility disclosed by Mendelian segregation must be viewed as one of the means of safeguarding the great ultimate (bio-economic) interests of the biological world, and that the incompatibilities here concerned are chiefly constituted by bio-economic and related biochemical factors. Will the union be a success from the bio-economic point of view, that is the question in every union of "gametes." Whilst in nature this is determined by various qualitative tests, such as prepotency and resistance to disease, the breeder, wittingly or unwittingly, generally sets aside the natural factors (together with other vital correspondences), and for a time is able to "breed" for the particular purposes he has in mind or, as the case may be, quite indiscriminately, although these may not be by any means the purposes of symbiogenesis. He relies for results on natural "endowments," but ignores their origin, their true significance and value.

If then, according to Mr. Shelton, it be that Mendelian inheritance accomplishes in various ways the same purpose as the mutual infertility of allied species, we may also say that it represents the natural tendency to prevent the very thing that domestication so generally induces, namely, loss of genuine bio-economic diversification and resultant retrograde compatibilities (fertility of a sort!), and we shall, therefore, be on our guard against all inferences from artificial experiments which fail to make allowance for the qualitative (bio-economic) purposes of nature, and deal with the most varying orders of factors in a promiscuous manner.

In *Nutrition and Evolution* (1909), I have already

expressed the view that Mendelian ratios of inheritance have reference to extrusion of impure strains, *i.e.*, their separation from pure strains, or, at any rate, a separation of strains according to compatibilities. This would seem to be in harmony with the fact that alternate (Mendelian) inheritance is the rule in the case of artificial varieties (which lack the bio-economic *raison d'être*), whilst in the case of natural varieties blended inheritance seems to predominate.

Mendelian ratios, as is well known, refer to cases where there occurs a pair of differentiated "characters" ("allelomorphs"), of which one (as is established by crossing) is generally "dominant" to the other. What is the meaning of this? Why are certain characteristics "dominant" and others "recessive"?

In Mendelian parlance these terms do not possess a qualitative connotation, but merely refer to the numerical part (the ratios) of segregation on the part of Mendelian unit "characters." They merely tell us in what ratios two "allelomorphs" (two somewhat allied but yet opposite "characters," which will not on crossing form a permanent blend) split up again on subsequent in-breeding on the part of the hybrids first formed. The "character" that comes out numerically strongest from the splitting-up process (segregation) is denoted the "dominant," and the numerically weaker the "recessive" character.

It may turn out, however, that in reality the (less conspicuous) numerically weaker "recessives" represent the superior value so far as viability and genuine survival-capacity are concerned. I hold that this is frequently the case, and I hold, further, that we are with these phenomena of mutual infertility primarily dealing with a biological antagonism which prevents the blending of "characters" under certain circumstances. This biological antagonism, I believe, is founded on values, *i.e.*, once biological values became established, and mutually related, the preservation and further enhancement of all that was (symbiogenetically

speaking) positive demanded its being in various ways antagonised to negative and disruptive influences.

In the web of life, as in human society, it is true that

Malus malum vult, ut sit sui similis.

Hence, in order that the danger of deterioration and reversion may be obviated it has become necessary that a deep-seated biological antagonism should separate the good from the (relatively) evil. In the Bible even we get a hint of a kind of biological antagonism:—

And I will put enmity between thee and the woman, and between thy seed and her seed.

Darwin and others noticed the extreme horror of apes and other animals at the very sight of a snake, the very type of predatoriness and degeneracy. This curious form of innate biological antagonism thus finds a rational explanation on my theory of biological values—of the divergent bio-economic paths—the one leading by way of symbiogenesis, the strenuous life and social co-operation to progress, and the other through reckless depredation, selfish exploitation and parasitism to degeneration and decay.

Frequently this safe-guarding biological antagonism results in slow eliminative processes analogous to the way, though more gradual, in which the digestive process or the intolerance of the body to poisons, acts as safeguards to health. Mendelian extrusion (of “recessives” or “dominants,” as the case may be) may be viewed as the genetic mode of getting rid of (bio-economically) undesirable strains, much in the same way as the various forms of bodily elimination achieve the riddance of the individual body from impurities. In the interest of values neither impurities, nor redundancy, nor swamping effects can be countenanced by Nature; hence the manifold forms of elimination, extrusion, and segregation.

Let us inquire a little further how there was developed this biological antagonism, which, in my opinion, is responsible not only for numerical but also (and indeed mainly) for qualitative distinctions, for real prepotency, for *genuine*

dominance, although frequently it may be the opposite of *Mendelian* "dominance," and rather to be found among the few and inconspicuous "recessives."

The fact that all strenuous organisms are directly involved in simultaneous progressive changes has arisen, as we have seen, from definite bio-economic necessities. The first necessities we found to be symbiotic necessities, *i.e.*, necessities of mutual labour and mutual diversification, *i.e.*, reciprocal differentiation. Without a fulfilment of these necessities there can be but a relatively insignificant production of values. It is not too much to say that in reality no single cell has ever been fertilised without the previous performance (by progenitors) of a series of symbiotic acts, as it is idle to suppose that without a previous production of values, reproduction can have any real biological importance, *i.e.*, every successive generation is subject to the same stress of circumstances, and must by its reaction thereto contribute its quota along the general line of development.

As we have already seen, with the multiplication of values and of individuals, symbiotic and colonising principles come early into operation. I have emphasised in my preface to *Evolution by Co-operation* how Robert Chambers' sagacity clearly perceived that though the "fecundity of nature" be such as to cause organisms in time to press upon the verge of the local means of subsistence, there is, on the other hand, a colonising principle which comes into play to meet the contingency of over-population. In other words, pressure of population results in new specialisations, new capacities, new values, and, concomitantly, in new forms and degrees of biological antagonism, according to the new forms and degrees of biological relatedness now arising.

That the principle of diversification is more profoundly effective than was hitherto supposed, we may gauge from the fact that according to recent biological observations no two cells are ever alike. Their dissimilarity, I should say, has reference in great part to the ever-changing bio-economic and

metabolic conditions of life. It is clear that the growing exigencies of the complex web of life require a continuous increase of symbiotic capacity. Hereditary similarity is in keeping with the identical discharge of hereditary bio-economic duty by progeny, and subsequent dissimilarity fluctuates with the fluctuations in such discharge.

We have seen that the nutrition essential to progressive diversification and to the co-ordination of cells even in the most primitive social state must, if it is to have permanence, be symbiotically acquired, failing which there is not even a metabolic possibility of successful co-ordination and diversification, be it for genetic or ordinary social purposes.

We have found that this is so because the production of nutrition itself, which after all is the first essential, is fundamentally from first to last a matter of joint production and of division of labour, *i.e.*, it depends on symbiosis. All of which points to the permanent necessity of continuous reciprocal and progressive differentiation of (unit and general) characters, and, if need be, also of various degrees of biological antagonism in accordance with qualification.

We have already noticed one form of organic antagonism particularly related to Genetics, the classical study of which we owe to Darwin, who expressed his results in the aphorism: "Nature abhors perpetual self-fertilisation," *i.e.*, in-breeding.

Another form of antagonism which I believe to be more fundamental still, I have expressed in corresponding terms thus: "Nature abhors perpetual in-feeding." And yet another form, also very far-reaching, I believe to be found in the application to the sphere of Biology of Gresham's law of currency, that bad money drives out good money.

In view of the common (bio-economic) cause of all these forms of antagonism, I believe the underlying truth can be expressed in a simplified form by the German aphorism: "Better is an enemy to good." And thus a simple, homely truth would seem to be at the base of much infertility in nature and of Mendelian segregation.

Bunyan's counsel, "Do well, better, best," seems to have been the motto, the "leitmotiv" of organic life for all these ages.

The antagonism between the better and the good is, of course, less pronounced than and of a different nature from that between the good and the bad. In the former case it is of a relative kind; in the latter it may be of an absolute kind. The former ends in mutual (symbiotic) accommodation; the latter in mutual destruction.

The slightly better organism in the normal course of evolution failing to find a perfect mate, frequently does not hesitate to unite with and to raise the slightly inferior mate, thus ending the mild antagonism, if any may be said to have existed. But the good cannot blend in the same way with that which is bad—nor the symbiotic with the totally anti-biotic—the divergence is too wide for an abiding union. The antagonism must persist until all can be made in their various diversified ways to conduce to the common good.

In other words there is a difference of antagonism which is one of degree and has its *rationale* in values. The problem is to achieve a degree of diversification which is bio-economically wholesome, and to obviate a degree being reached which would become dangerous to the balance of life.

In the *Scientific American*, Supplement No. 2,036 (Jan. 9th, 1915), Dr. W. P. Jenny describes the method followed whereby the hybrid Japanese morning glory (*Ipomœa Chinensis* + *Calonyction Speciosum*, i.e., flowers of different genera of *Convolvulaceæ*) is made to reproduce itself *true* from seed, the Mendelian second generation being ingeniously avoided by repollenating the hybrid with the pollen of a male parental form (pollen from the white moonflower, *Calonyction Speciosum*), whereby no true "second generation" occurs; but only a series of progressive "first generations," on which the Mendelian law has no action.

This method ("dual fertilisation"), then, contrives to re-introduce an essential bio-economic stimulus obviating to

some extent the deficiency resulting from artificial and unredeemed, *i.e.*, Mendelian in-breeding—severely restricting as it is the complete operation of the hereditary mechanism, particularly that portion of it which is inherent in the symbiotic environment. Though still artificial, the experiment is analogous to the case of stock + scion (rather than scion + scion), *i.e.*, Dr. Jenny's ("re-inforcing") method somewhat restores useful reciprocal differentiation and thus re-introduces a truly viable element. We thus approach symbiogenetic conditions, whilst the Mendelian method of "selfing" in reality, and for the time being, almost completely *suppresses* symbiogenesis. It is all, again, a question of relatedness.

In his treatise on Friendship ("Lysis"), Plato tells us that he has heard it said that frequently like is most hostile to like, and the good to the good, and that generally things most like each other are most full of envy, strife and hatred.

But the antagonism we have here (envy!) is merely a distortion of what I now might term "wholesome antagonism," which purports emulation rather than jealousy, and wholesome diversification, specialisation and co-operation rather than sanguinary competition of idlers for one and the same object.

Some of the ancient Teutons when asked by Tacitus why they abhorred even a modicum of work and industry, replied that it seemed easier to them to get what they wanted by warfare.

Such iniquitous thoughts and forms of antagonism were quite common among some ancient peoples, many of whom imagined that warfare was quite the most legitimate and the noblest method of wealth-getting. It has taken us many centuries of sanguinary experience to learn that this is not so, and that the true and normal relation between nations is one of co-operation. It was Grotius, I believe, who in the seventeenth century first clearly enunciated this truth, although credit must here once more be given to the Old Testament for uttering the pregnant warning: "Because thou hast spoiled many nations,

all the remnant of the people shall spoil thee." The same fundamental truth as appertaining to the relations between the different species, genera, and orders in nature, involving a recognition of "the everlasting difference between right and wrong," has not yet found its way into Biology. Plato, at any rate, has shown that internecine and international warfare is a vicious state, and that its cause is usually connected with physiological excesses and resultant decay of character.

Similar to those partly true notions of Plato's time anent the hostility of like to like, Darwin's metaphorical "struggle for existence" is supposed to refer principally to the (natural?) "enmity" between brothers and cousins, and Sir E. Ray Lankester tells us: "The survival of the fittest alludes exclusively to the struggle within the borders of a race," that is to say, attention has been mainly devoted to that aspect of the struggle.

Again, we must say that the "struggle" (so far as it is the lethal struggle, at any rate) has reference to those brothers who for some reason or other (chiefly metabolic!) fail to enter into proper relations of reciprocal differentiation with each other.

"If thou wilt take the left hand, then I will go to the right; or if thou depart to the right hand, then I will go to the left."

From Darwin's admission of the advantages of diversification it is not a far cry to the recognition that normally what slight (economic) antagonisms between brothers is permissible and even desirable, should only amount to a matter of mutual accommodation through co-operative diversification.

The one great lesson, however, that we can glean from all these considerations is that there is an "antagonism"—from the noblest forms of "allelomorphism," *i.e.*, wholesome diversification, to the most gruesome forms of mutual (competitive and morbidly instinctive) hatred—pervading all nature in accordance with values, purporting the continuous sifting of the grain from the chaff, and resulting in the establishment of a hierarchy of beings in accordance with their deserts.

That there exists in nature an obvious antagonism between those of a community which contribute to and raise the common good, and those the activities of which tend in the opposite direction, is borne out by many facts. We see that the drones of the bee are mercilessly slaughtered (eliminated) with the approach of the winter, for their biogenetic value to the community cannot make up for their bio-economic uselessness. We can find similar "extrusions" in hundreds of other instances. We find many cases of recognition of superior value and even of property rights by social animals, and frequently a community will inflict the penalty of death upon a member guilty of what it considers unsocial conduct.

Now, Mendelism—although sadly lacking, in my opinion, in qualitative analysis—confirms in some detail the account of natural antagonism as I have so far outlined it, as a little further consideration will show. Mendelism is supposed to have brought home to us the idea of a living organism as built up (in part at least) of numerous unit-characters which—much like Mr. Davidson's plantagens—behave as indivisible entities, and, like the plantagens, have definite predilections and affinities according to the factors that are "co-operating" in the compound.

We saw that it was the general form of co-operation (symbiosis) in a plant that determined the success or otherwise of a particular plantagen-community, and we may conclude that in a similar way it is the degree of bio-economic appropriateness which ultimately determines whether any unit-character is worth retaining, or has perforce to be retained.

The discovery of indivisible units has called forth the expression "the atomic constitution of organisms"; a statement which may easily become misleading if a complete rigidity of biological characters, and a behaviour of characters irrespective of symbiogenesis, is thereby suggested. Of course there are atoms and even groups of atoms—as there are also

organs—in the constitution of an organism, but they all constantly affect and change each other, according to the changes in the central authority. What is more striking is the similarity which the facts of chemical affinities, attractions, combinations, and substitutions bear to the facts of biological (or physiological) affinities and substitutions on the part of certain biological units, behaving as indivisible entities, but even so it does not follow that the organism is reduced to mere mechanism.

The behaviour of these entities, apparently resembling very closely that of chemical elements, requires some little explanation, for it must be remembered that the facts of chemical affinity are still quite mysterious.

We should like to know the reasons for the strange forms of relatedness of units and of things generally.

Here the analogy with the plantagens helps us rather more than with the minerals, for we saw the behaviour of the former associated with bio-economic factors, and I believe that the affinities which we are beginning to see in Biology will materially aid us in the interpretation of inorganic combination. Just as we found these bio-economic factors determining the bio-chemistry of life, so these factors will probably be found also at the root of the strange seemingly chemical manifestations of Mendelian indivisible entities.

Sometimes these entities will blend and form a genuine (*i.e.*, fixed) inheritance, and sometimes they will not, but split up again and segregate in subsequent generations. They thus behave not unlike plantagens and other symbiotic partners, *i.e.*, under adequate symbiotic conditions they produce a permanent (sexual) union; *i.e.*, a blend, or, in the alternative, only a transitory and infertile union.

Of Mendelian "characters" there is, of course, such a promiscuous assemblage that they are bound to be involved in a thousand and one different affinities, and before we can apply the same reasoning as to the plantagens we shall have to sift the grain from the chaff.

The mere possibility of producing a cross at all between two "allelomorph" characters does not in all cases prove the existence of sufficient compatibility to overcome in the long run the otherwise existing (bio-economic) antagonism that really separates the two entities. Prof. A. Dendy states that any two organisms sufficiently nearly related to be capable of crossing are identical as regards the vast majority of their characters; but though this be true, I would point out that, nevertheless, the two organisms may have been tending too long in bio-economically divergent lines to constitute fruitful alternatives. Eventually—as between cross-feeders and in-feeders, for example—a stage of biological antagonism may be reached which is past reconciliation. In any case we must consider that there are many gradations of "allelomorphism."

We may say that though frequently (particularly in artificial cases) many "characters" are called, few are chosen, and that the perpetual union of certain "characters" is for very good reasons "abhorred" by Nature.

The last thing to be expected on my theory of biological values would be to find that certain pairs or characters should eventually behave otherwise than antagonistically, although by virtue of community of descent they retain slight affinities and a degree of compatibility sufficient for Mendelians to call them "allelomorphs"; but they are in reality quite different in constitution and *bio-economically* (or *symbiotogenetically*) speaking on widely divergent paths of evolution.

Obviously Mendelism has failed to make the necessary qualitative distinction between good or bad pairs of allelomorphs, as it also begs the question of (or has nothing to say on) the origin and the significance of these "characters," as Darwinism begs that of the origin of variations and of progenitors.

Just as Darwinism, although supposedly a theory of evolution, has its *deus ex machinâ* in the common progenitor, so Mendelism, also by some believed to be a theory of evolution, speaks of an original hereditary "hold-all"—an

“Ur-organismus”—(a sort of archetype), the gradual “unpacking” of which has constituted evolution.

In their indiscriminate way of dealing with genetic phenomena, many investigators have quite overlooked the fundamental fact that in producing a cross they are really experimenting in symbiogenesis, or, at any rate, that their reliance must be on what has been symbiotically established, and, further, that in all cases a certain amount of reproductive expenditure also has to be allowed for.

What proceeding could be more promiscuous, for instance, than to cross an obviously diseased strain (disease being the antithesis of symbiosis) with one that is healthy, in the hope of producing normal effects? Yet it is done wittingly and in all seriousness in many cases, and in many more, of course, quite unwittingly, because of the lack of proper recognition of pathological states. The result of crossing is either that you produce a resultant greater than that of either of the individuals, or, if there is morbidity in one or the other of the individuals, a resultant of somewhat reduced viability. In all cases there is a disturbance of the moving equilibrium, which subsequently proceeds to re-arrange itself through segregations and eliminations, according to the strength of the new resultant, to the new compatibilities of the case. If it be a wholesome cross, much of that which is dispensable of old material can now be eliminated, on the principle that the better is the enemy of the good.

In the alternative, what had been added of noxious strains must be extruded where possible, even sometimes at great expense, in order to restore a sufficiency of unencumbered vitality. If it were otherwise, if crossing *per se* meant the achievement of a perpetual union of all there is of good and of bad “characters” in the parents, then, indeed, evolution would be quite a haphazard matter and quite as much a matter of retrogression as of progress, as many are driven to assume by their inadequate conception of the real driving factors of the

process. Then, indeed, there would be little object in believing (and some deny it) that Nature abhors certain modes of breeding and of feeding, because antagonistic to the fundamental bio-economic principle.

Evolution on such a chaotic view would not be much more than a matter of haphazard variations and haphazard crossing (assisted by local expediency), whilst in reality it is a matter of work and production of values first, and the sexual part is only one of the methods of the gradual fixation and accumulation of values.

It is not in vain that every organism is under the primordial necessity to pass in its development through the primitive unicellular condition, and the obvious costliness of this vital and indispensable process should put us on our guard and shew us what values are concerned when we see such elaborate safeguarding processes in operation, and that in general the maintenance of values is a prime concern of Nature. Any would-be imitation of the natural method which leaves out the implied concern for bio-economic values is doomed to failure, or, at any rate, it is not likely to give us reliable information about the true ways of Nature.

I have referred to Plato's anticipation of Darwin in the matter of the hostility between relatives, and as the treatise on Friendship bears in a marked way on the question of the relatedness of things, and, hence, is calculated to throw light on the similarity of behaviour in chemical elements and in Mendelian entities, and on the substitution of certain affinities by others, it is worth while to go into the matter a little further.

Plato in telling us of the notion of some of his contemporaries, that frequently like is most hostile to like, and the good to the good, adds that this is so, because the like can derive no benefit from the like. In other words, and as I have already been at pains to point out, the antagonism arises only with a failure of sufficient symbiotic relation. Plato, for

argument's sake, puts the case in the extreme, as he also does the obverse case:—

But such as are most unlike are most disposed to friendship, just as the dry desires the moist, the cold heat, and so on. . . .

The contrary is most friendly to its contrary.

• It is clear that what he is in reality driving at is the demonstration of the need of a genuine pair of symbiotic opposites—not by any means necessarily widely antagonistic—to establish evolution by joint operations (symbiogenesis).

He tells us that that which desires, desires what it stands in need of (*i.e.*, reciprocity), and that which stands in need (what is there that does not?) is friendly to that of which it stands in need. (Hence genuine symbiosis involves friendliness and not hostility.)

He was, of course, also well aware that “the more wicked men are the more hostile they are to each other,” so that the degrees of antagonism would be quite different in accordance, as we should say, with symbiotic possibilities.

Like good and like bad are antagonistic to each other, but in totally different degrees and to totally different purposes.

The antagonism of the former is capable of finding, and usually does find, relief in emulation and subsequent blending of the results of work, while that of the latter produces the intense competitive “struggle for existence.”

Allelomorphism, like friendship, thus ultimately depends on mutual usefulness, and “friendly” antagonism frequently may not mean much more than the sacrifice of the lower for the higher.

Mendelian segregation has brought to light the fact that the presence of certain “characters” is not always indicated by the ordinary appearance of the individuals; not always does the plume proclaim the fowl. It is necessary, in order to gauge its composition, to “break up,” as it were, an organism by the selective effects of crosses followed by in-breeding, which I call genetic manipulation. I have already indicated that pathological components gradually tend to give a peculiar

conspicuousness to a species and lead to all manner of adventitious development apt to obscure the residual normal developments. How well Plato's extraordinary biological insight forestalled these conclusions, is evident from the following of his remarks: "Some things are themselves such as that which is present with them, and some not."

As he speaks of disease in this connection, it is obvious he wants to demonstrate the truth that organisms when they become over-specialised to such an extent as to lose their true symbiotic balance, show a striking conspicuousness of adventitious (pathological) developments apt to obscure the residual normal "characters." Such organisms are more like that which, by their morbid appetites, they have attracted to themselves, than that form which the species represented in earlier and healthier times, a truth also borne out by embryological facts. "That, then, which is neither evil nor good, sometimes when evil is present, is not yet evil, but sometimes it has already become such." Thus Plato indicates how good and evil strains compete for predominance, though apparently outwardly all is peace—peace, peace when there is no peace—and how anti-biotics may eventually prevail. He also shows us how every encouragement of the latter must encourage evil correspondences: "When, therefore, it is not yet evil, though evil be present, this very presence of evil makes it desirous of good, but this presence which makes it evil, *deprives it at the same time* of the desire and friendship of the good." (Italics mine.) It is clear that in all cases qualitative tests have to be applied before we can know what "materials for variation" we are dealing with, before we can deal adequately with morphogenesis, or with genetic physiology.

We have already inferred that normal organisms are those which refuse to over-specialise in any direction so as to become slaves to a peculiar environment or to particular circumstances.

Plato really wishes to drive home the same lesson by emphasizing that general integrity which we have already found to be the best guarantee of a genuine symbiotic balance

of biological relatedness. Such integrity of character is, indeed, the truest safeguard of genuine friendship—as distinguished from transient forms of alliances of expediency, miscalled “friendships” (pseudo-symbiosis), which usually end when the particular expedient purpose which they served fails to manifest itself—as it is also that of genuine symbiogenesis.

There is, as is well known, a constant danger of over-specialisation (extreme specialisation, extreme determination) in certain directions, and a proper cross—one that receives its legitimacy from adequate symbiotic factors—is known to be of good effects in neutralising at least some excesses and making good some deficiencies, which shows that a cross signifies much more in general qualitative and bio-dynamic effects than Mendelism would lead us to suppose. We shall see more evidence thereof later on, and we shall conclude all the more certainly that knowledge of the causes and the degree of friendship or antagonism—relative and absolute—obtaining between genetic units or even biological substances, just as between organisms themselves, is essential to proper, *i.e.*, discriminating genetics, requiring, as it does, a proper biological diagnosis.

Making due allowance for the bio-dynamic effects of adequate crossing, and for what is entailed in the previous maturation of the uniting elements, we may say that such crossing achieves nothing less than the transmutation of organic currency, *i.e.*, products for exchange—in particular that of the genetic and nutritive kinds, *i.e.*, it presents a genuine form of biological “alchemy” through symbiogenesis.

In order to understand the true significance and alchemy of crossing, however, it must again be emphasised that it is preceded by that other alchemy of nutritional “amphimixis” on which I have repeatedly insisted. Indeed, the part played in symbiogenesis by nutrition is so great that frequently, as is well known, a nutritive stimulus is enough to start the all-

important function of fertilisation. The transmutation begun by nutritional amphimixis merely receives definite, specific and enhanced expression through that *élan* which accompanies fertilisation. The transmutation is thus also carried one step further by sexual reproduction, which by effort calls forth the highest form of symbiosis (*viz.*, internal co-operation) that a species is capable of, and this in turn is only possible with these highest forms of specific symbiosis, as we have seen in the case of plantagens.

Continuing the metaphor, we may say that the alchemy of life is constantly endeavouring to synthetise the existing biological elements or substances into higher forms, producing a kind of transmutation of these elements similar to the transmutation of the baser into noble chemical elements, and similar also to the transmutation of forces (and materials) produced by the photosynthetic activities ("work") of the green plant. Given the maximum of required stimulation in any direction—particularly in the symbiotic direction, as so ideally provided by the processes of sexual reproduction and of fertilisation—and alchemical "reaction" is set up and a transmutation of substances results. This may be either progressive or degenerate. These biological products, higher and lower, in circulation in the organic world are, too, subject to a law like that of Gresham in currency whereby the lower will, under certain conditions, drive out the higher form. Biological "gold" (suddenly, so it seems) appears in the place of silver, or, in the alternative, a retrogression supervenes when the higher currency, in obedience to an eternal antagonism, has to give way to a less noble one.

The part played in these developments by Bio-Chemistry and Bio-Dynamics is, as we have seen, determined by Bio-Economics, and the three factors together may be said to make up the complex of agencies which maintain the alchemy of life. If it is a case of bad currency driving out the good (*i.e.*, retrogressive evolution), the disruption and sundering of symbiotics may be accelerated and thus produce many startling

phenomena, comparable to those of the dissociation of matter (radium!) which is the obverse of progressive transmutation or integration. Thus we meet with "sports," "heroes," "mutants"—*salta*.

Just as the dissociation of chemical elements throws light on their genesis, so organic "dissociation" helps us to understand organic integration by symbiogenesis. The phenomena seem to be parallel throughout. The stimulations tending to disruption are identical in Chemistry and Biology, *i.e.*, faulty association, due to the presence of impurities, showing that the symbiogenesis is obstructed or disturbed. This I have already pointed out in my previous writings. Failing these symbiogenetic explanations, Mendelism is driven into the Mutationists' camp.

As to the origin of a positively new feature, Mendelism is professedly quite in the dark. As Prof. R. C. Punnett says: "It (the new feature) turns up suddenly, complete in itself, thereafter it can be associated by crossing with other existing characters so as to produce a gamut of new varieties."

For the riddance of impure strains in subsequent generations, the normal safeguarding effects of the fertilisation process are relied on since these re-assert themselves at the first opportunity. But even the good services of the fertilisation process, together with general vitality, must eventually be strained to breaking point if impure strains continue to be poured into the racial composition. Fertilisation, under such circumstances, though we try to cross certain otherwise apparently well-established varieties with contrasting "characters," can no longer yield results, not even (retrogressive) Mendelian or Mutant phenomena. Instead, we meet with sterility and exhaustion. In other words, the limit of the benevolence of the fertilisation process having been reached, further hybridisation becomes impossible.

Seeing that so many "characters" appear in a brusque manner, apparently non-gradual and arbitrary, Mendelians think they must adapt their argumentation anent evolution to

that of the Mutationist school, and at the same time eject every notion of utility from the conception of the evolutionary process. But we have now sufficiently seen that all genuine up-building processes depend on gradual symbiogenesis, including in Robert Chambers' parlance various forms of "the long-protracted gestation of nature," and though this must become more effective every day, yet it remains inherently true that *Natura non facit saltum*. Nature is progressing slowly, and this for very good qualitative reasons. There are no jumps, though occasionally through degeneration big falls will occur. In the event of the disruption of the equilibrium through the introduction of a strong genetic dose of anti-biotics (inferior currency) the resultant becomes lowered.

Nature meets the case as best it can. The cross-fertilisation responsible for the result may have less permanent effects than in-breeding frequently has, and with subsequent in-breeding a separation of strains may take place. In-breeding alone tends to fix the type, though, if long continued, with grave dangers of disease and ultimate extinction.

The method of segregation is to encapsule, as it were, the inferior strain—in a manner similar to that whereby certain animals by means of a secretion seal up intruding pathogenic organisms—and then to extrude the "alloy" on the first opportunity. The fact that fertilisation has taken place at all means not much more than that over and above the provision of a just sufficient genetic stimulation, an "infection" has been provided, and that in the new generation an organic "alloy" has been formed. It is also obvious that the eventual riddance of the impure strains so "alloyed" with pure, is a more or less expensive process, during which a considerable amount of vitality may have to be sacrificed.

In my *Nutrition and Evolution* I have referred to the fact that a cross between an immune and a non-immune strain of wheat from "rust" fungus disease results in hybrids which are all susceptible to "rust," and that immunity in this instance behaves as a recessive to the non-immune condition.

This seems to indicate that the result of a cross must always depend on qualitative factors, or as I now, in keeping with the further elaboration of my theory, would say—it depends on the presence of symbiotics, *i.e.*, symbiotically accumulated ancestral forces. We have seen, in the case of grafting, how the physiological *misère* of our cultivated plants may be somewhat relieved by the introduction of symbiotics borrowed from a wild stock. This is crossing of one kind. To introduce, instead, diseased strains—equivalent to anti-biotics—into the already declining constitution of the over-cultivated wheat, however, is crossing of quite another sort, and is bound to produce a lowering of the resultant. Just as we saw that this leads to disaster in nature generally, and just as even cross-fertilisation in spite of its manifest advantages is frequently impracticable in cases of physiological *misère*, so in this artificial case the introduction of anti-biotics leads to an increased liability to disease generally. The fact of the diseased condition thus becoming “dominant” and the healthy factors being “latent,” “recessive,” *i.e.*, diminished, in my opinion is of greater significance than the fact that hybridisation with subsequent (more or less) definite ratios of segregation is still possible. It is now a case, as Plato would say, where a thing has become like the evil that is present within it. But the good that the thing contained may, at least, partially be recovered. (It is known that “dominance” is imperfect in the F^1 generation, and that more or less of the recessive “character” is generally outwardly exhibited; which would seem to indicate that all health, although obscured, is not gone.)

The danger—which is the danger of exhaustion and of biological sterility—is, in Plato’s words, that the presence of evil may be such as to deprive the organism at the same time to an increasing extent of the desire and “friendship” of the good.

Nature, ever wisely conservative, preserves for a time at least, the evil for the sake of the little good with which it is still associated, even as the destruction of that ancient city of

Sodom might have been obviated had, at least, peradventure "ten righteous men" been found there. But there was found only one who had retained the desire and the friendship of the good, and lest he should be swamped by or destroyed with the evil and be doomed in the great crisis that was to supervene—lest the breeding of nothing but evil should continue—he had to be segregated.

Thus Scriptural and Platonic Biology are, in reality, quite at one with modern Biology.

We can also see that no Mendelian character can ever behave as though it existed by or for itself only. It is possible—and it is of the utmost interest to be well established—that the integration of every progressive feature deserving of the name is by an interplay of opposites (allelomorphs); but we must not lose sight of the fact that in nature it is symbiogenesis, in the widest sense of the word, that is aimed at.

Eventually, however, in the case of the diseased wheat, on self-fertilisation "recessive" immune seedlings appear in the ratio of 1:3 to "dominant" "rusty" seedlings; *i.e.*, as I would interpret it, previous conditions of health re-assert themselves concurrently with a costly extrusion of impure (though "dominant"!) strains. Generic recovery is purchased by the wheat at the price of "extruding" three-quarters of a generation as "rusty" elements. It is a kind of "self-pruning." An organism that is to be of some bio-economic use can afford to harbour only a limited amount of encumbrance for any length of time.

That cultivated plants do not really present instances of genuine immunity is borne out by the fact that *Heterodera*, a noted *Nematode*, is capable of working immense havoc amongst them, particularly where the soil is damp, whilst its presence has actually been found to be advantageous to plants that grow wild (in deserts), which, not being surfeited, have been able to maintain a high degree of resistance to disease *pari passu* with the capacity for wholesome biological symbiosis. The case shows that "immunity" is a relative concept, and

that genuine symbiosis is the antidote of disease, and, further, that in nature everything depends on the degrees of relatedness and on values.

It also shows, again, that ancestral dynamics consisted primarily of symbiotics, and that frequently the advent of "partial luxury" changed a one-time wholesome, valuable and symbiotic relation into an unwholesome and parasitic one. That such an account of the arrival of anti-biotics represents the correct history of the transformation implied, seems to be borne out by the established facts of the frequent degeneration of recognised cases of symbiosis into parasitism so soon as the symbiosis ceases, and, further, by the fact that (as pointed out by G. Massee in the August number, 1910, of the *Naturalist*) a case of rampant parasitism may easily be seen to arise from a milder form, as in the case of certain fungi that are only known as pure saprophytes, but can by a "judicious" (!) course of training be taught to become rampant parasites.

That these qualitative explanations are essential may now also be seen in their application to the case of Mendelian or alternative inheritance, as presented by Mr. Ch. Walker, D.Sc., in his article on "The Interpretation of Factors in the Study of Heredity." (*Science Progress*, Oct., 1913.)

"Are all characters inherited in this alternative manner?" he asks, and he quotes the view of Prof. Davenport (1906) that "very frequently, if not always, the 'character' that has once been crossed has been affected by its opposite with which it was mated and whose place it has taken in the hybrid. It may be extracted therefrom to use in a new combination, but it will be found altered. This we have found to be true for nearly every character sufficiently studied."

In any case, whether all "characters" are inherited in the Mendelian manner or not, we thus have a confirmation of the fact that hybridising two gametes, over and above a mere "chemical" union, produces bio-dynamic effects such as those that I have classed as symbiogenetic or "alchemical," i.e., they are productive of slow transformation (changes in the

germ substance) according to the metabolic and bio-economic compatibilities of each case. These gradual and far-reaching bio-dynamic effects must not be left out of consideration any more than the bio-economic effects resulting from the production of "love-foods," which we have found to be so profoundly significant.

An example of negative bio-dynamic effects we saw in the case of crossing with "rusty" wheat. Other similar effects seem to be presented by the phenomena of telegony, which, though it is not considered an established fact, is yet believed in by practical breeders. The word Telegony means reproduction influenced by a remote agent, and Sir E. Ray Lankester suggests that the hypothesis that the offspring of a known sire sometimes inherit characters from a previous mate ("infection") of their dam is not improbable. The same writer states that amongst breeders of horses and dogs the selling value of a dam which has borne young to an inferior sire, or to one of a distinct species, is largely diminished as compared with that of a dam which has been mated only with a first-rate sire of her own breed. Amongst plants the "infection" of the mother by fertilisation, causing the tissue surrounding the germs to grow and to swell up and to form the "love-food," *i.e.*, the seed coats (the pulp and the "rinds") and the fruit, also occurs in the case of the fertilisation of one species by another.

It is found that if an orange-flower is deliberately fertilised by placing on its pistil the pollen-grains of a lemon-flower, not only are the ovules of the orange fertilised, but the surrounding structures, which enlarge to form the fruit and are parts of the orange-plant quite distinct from the ovules, also become affected by the pollen.

The same thing has been observed in apples, melons, orchids, rhododendrons, grapes, maize and peas, when one variety has been fertilised by the pollen of another, or when one species has been fertilised by the pollen of an allied but distinct species. The fruit in these cases (not simply the germ—the young plant within it) has been found in some instances to have some of the colour, flavour, or shape and marking of the fertilising variety or species blended with that characteristic of the fertilised variety or species. The egg-producing or mother plant not

merely has its ovules fertilised, but its tissues for some distance around are infected and made to take on, in their living, growing substance, some of the quality of the fertilising species. A similar thing occurs, though rarely, when cuttings of one plant are grafted on to another. The living tissue either of graft or of stock, and sometimes of both, is affected by the fusion with it of the tissue of the second plant united with it. And this appears to be a kind of "infection"—living particles passing from one to the other and producing a blend of the two kinds of living substance characteristic of each of the united plants.

Such cases, then, show the enormous symbiogenetic possibilities of fertilisation and of crossing, and they may now be seen to support the view here taken of evolution by symbiogenesis, *i.e.*, the gradual and progressive transformation of organic forms on bio-economically pre-determined lines according to mutual, social, or biological values.

"Now it is quite obvious," continues Dr. Walker, "that the bulk of the characters in any individual are not inherited in the alternative manner. Whether they originated in the remote past from characters that were Mendelian is beside the question; they certainly are not so now."

I should say, however, that it is of some considerable importance to know whether the bulk of "characters" not now inherited in the alternative manner did in reality originate in the remote past from "characters" that were (mildly) Mendelian; whether, as I would say, symbiogenesis working through reciprocal differentiation has not at all times been the true *fons et origo* of all progressive change? Why should we always shun the question of origins?

Alternative "characters," I submit, imply on the positive side and primarily the preparation and maturation of genuine pairs of reciprocal opposites which normally combine and blend their forces in genuine amphimixis, and—given a sufficient super-adequacy of forces jointly evolved—in genuine symbiogenesis. (Failing the symbiogenetic explanation, Prof. Dendy seems to me perfectly justified in protesting that it is "a grotesque view" to assume that all species have arisen by "crossing."*)

* British Association 1914.

The case of Mendelian alternatives would thus resolve itself into one of subservience to the one great cause of progressive evolution, *i.e.*, to the joint production of values—a view which is in harmony with the most modern conception of the fertilisation process, both as a safeguard of racial purity and as a means of progress through amphimixis.

Speaking of man, Dr. Walker says:—

To me, therefore, it appears perfectly clear that the overwhelming bulk of the characters inherited by every individual is derived from very remote and prehuman ancestors. . . . The characters common to all individuals obviously cannot be transmitted alternatively. They are always present. It is therefore evident that the characters that are inherited in the Mendelian manner are really slight additions to or subtractions from such characters already present.

This, of course, would scarcely affect the argument that *originally* everything depended on reciprocal differentiation, on symbiogenetic methods. Sure it is that even that great bulk of “characters,” which have now become so fixed as no longer to need this interplay of alternatives for their very establishment, still depend for their maintenance and permanence on due biological symbiosis with the pre-requisite of proper domestic symbiosis.

The racial acquisitions—ancestral capital—are so much older and so much more powerful than recent individual additions, that we must expect the latter to be only slightly fixed, and hence also more evanescent in their effects than ancestral endowments. It is always the latest acquired endowments that go first when degeneration supervenes. As Dr. Walker himself tells us on another page:—

Of the whole stock of characters present in an individual then, the great bulk has been derived from remote ancestors. This stock is constantly being varied by what are comparatively small additions and subtractions. Some of these are variations of the individual organism and its *private property* (*italics mine*), so to speak. They may be transmitted with increase or diminutions to the offspring. Thus it becomes evident that a number of these smaller characters is inherited from near ancestors.

Precisely. There is racial (communal) physiological property and there is individual (private) physiological property. The former is by far the more important, established as it is by protracted endeavour, solidly supported by a number of biological correspondences, fixed and purged by repeated fertilisation processes. It stands to reason, therefore, that the more evanescent "characters" are generally of comparatively recent origin, and that they constitute no more than "private" property which has not yet been through the "Mendelian" mill sufficiently to constitute it racial property. It has yet to be proved by various biological (bio-economic) tests whether this "private" property contains elements that can presently be turned to good racial account or otherwise.

The legitimacy of "private" property thus depends on much the same factors in organic as in human society (and so does that of "distribution" of wealth generally). As Ruskin has it: "Wealth ill-used is as the net of the spiders, entangling and destroying; but wealth well used is as the net of the sacred fisher who gathers souls of men out of the deep."

Dr. Walker also says that domesticated races possess a character in common, or rather an exaggeration of a character which is not present in wild races. In my opinion, this consists mainly in the fact that they are surfeited because deprived of a genuine bio-economic independence—a similar bio-economic retrogression producing similar metabolic abnormalities, and similar exaggerations everywhere. Just as in human society the institution of slavery always produced unfavourable (dysgenic) "characters," or tended to exaggerate existing unfavourable ones, so the one-sided exploitation of organisms in domestication results in undesirable abnormalities and exaggerations.

The common tendency, as is well known, is to produce "large" variations, *i.e.*, bulk at the expense of symbiogenesis and of survival values.

The domesticated races are also notable for their greater variability than wild races. This is, according to Dr. Walker,

because man has always selected animals or plants which vary from the mean of the race more than did their fellows. "Whatever else he has selected then, he has always selected *variability*, which is just as much a character as anything else."

If we allow "rustiness" and susceptibility to rust, etc., to be classed as "characters," there is indeed no reason why we should not treat "variability" in the same way. But the "variability" that lends itself particularly to exploitation, as instanced by the case of the relations between retrogressive algæ and retrogressive *Convoluta* and by the parasitic nurture of domesticated races by man, must certainly be held to be a bad "character." "Good" variability is slow variability. It is considerate and therefore constant in character. There are many ancient obligations, many enduring bio-economic correspondences to be considered, and its direction is towards increased direct service to the biological community. "Bad" variability is regardless of the bio-economic bond, and, like depravity, travels more swiftly. It is more akin to disruption and similar to the dissociation of metals, which is also distinguished by many startling features.

It cannot, however, escape its fate, nor for a time help being at least indirectly serviceable, being itself exploited as it was "out" to exploit rather than to serve.

Those characters which in the domesticated races behave in the Mendelian manner, may therefore reasonably be considered as recent variations in individuals which have been *rapidly exaggerated*. (Italics mine.)

We have here precisely the antithesis as constituted I believe by symbiotics and anti-biotics.

The exaggeration of recent dynamics (unfavourable or negative in the bio-economic sense) has taken place at the expense of former favourable positive (ancestral) dynamics, and—as usual with the concomitant tendencies in the direction of abnormal bulk and of "large" variations—we thus approach the goal of extinction rather than return to the path of symbiogenesis.

If we have here, as I believe, a genuine disruption we can well understand that Mendelian methods of breeding are bound to exhibit a multiplicity of segregations and also of new combinations. When a complex community, once flourishing and rich in correspondences, starts on the decline, some of the component parts at least will not break up altogether, but enter into fresh combination with others that have remained tolerably wholesome and sufficiently sympathetic.

Dr. Walker thinks that many of these "large" or "exaggerated" variations running riot from time to time, if left to themselves, would have come to ruin. But man came to the rescue and protected (whilst exploiting) them. Again we have thus the parallel with the case of algæ and *Convolvata*. In some cases when the exploitations of a plant by man has finally transformed it into a monster, he ceases to cultivate it and takes others under "cultivation" (exploitation), with the same ultimate effects as in the case of the parasitic nurture of algal cells by *Convolvata*. It all shows that eventual mutual infertility is the result of retrogressive symbiosis, and, inversely, eventual ability to blend the result of sufficient symbiosis.

The view that in domestication we are generally dealing with an induced parasitic diathesis and a partial disruption due to surfeit and the prevalence of anti-biotics, may also be seen to receive corroboration from the following remarks of Prof. Klebs in his contribution to *Darwin and Modern Science*:—

It is, however, a fact that when a plant is removed from natural conditions [from the bond of normal bio-economic co-operation] into cultivation, a well-marked variation occurs. The well-known plant-breeder, L. de Vilmorin, speaking of his own experience, states that a plant is induced to "affoler," that is, to exhibit all possible variations from which the breeder may make a further selection only after cultivation for several generations. The effect of cultivation was particularly striking in *Veronica chamædrys* which, in spite of its wide distribution in nature, varies very little.

After a few years of cultivation this "good" (*sic*) and constant species becomes highly variable. The specimens on which the experiments

were made were three modified inflorescence cuttings, the parent-plants of which certainly exhibited no striking abnormalities. In a short time many hitherto latent potentialities became apparent so that characters, never previously observed or at least very rarely, were exhibited, such as scattered leaf-arrangement, torsion, terminal or branched inflorescences, the conversion of the inflorescence into foliage-shoots, every conceivable alteration in the colour of flowers, the assumption of a green colour by parts of the flower, the proliferation of flowers.

Prof. Klebs goes on to say that:—

All this points to some disturbance in the species resulting from the method of cultivation. It has, however, not yet been possible to produce constant races with any one of these modified characters.

If many plants, in spite of wide distribution in nature, vary very little, this is, I maintain, because of their steady function, *i.e.*, because of their wide bio-economic usefulness and connected constancy of (good) character. So long as they remain tolerably within the bond of bio-economic co-operation, so long as they maintain a tolerable bio-economic specialisation they remain, *ipso facto*, “good” and “constant.”

If, in the alternative event, they are showing a multiplicity of puzzling new “characters,” this is not surprising in view of the wealth of physiological capital accumulated during the periods of strenuousness. It is not surprising that the wealth of symbiotics can be diverted into many different channels and used for a plurality of new combinations, although—or perhaps all the more readily because—the constitution of organisms is “atomic,” and segregations and re-combinations depend on the absence or presence of certain “factors.” We have already seen that the advent of surfeit and of “protection” must produce a general relaxation of strenuousness and a loss of the powers of work. “Eine überreichliche Nahrung gebiert wunderliche Laster,” as Nietzsche has it. Surfeit also produces puzzling transformations. In a similar fashion mercantile wealth when no longer employed in a particular trade may be, and often is, turned to a plurality of uses—some productive and others less so, some to endow learning, science and art, others to make further

“profits” in anti-social parasitic trades. In every case “characters” would vary with the trade; if the trade is anti-social, new “factors” will constantly arise tending to render the trader increasingly anti-social and anti-eugenic. In a similar way we have seen that loss of symbiotics means loss of valuable biological correspondences, and hence it may also mean the advent of a plurality of new “factors.”* If we understand the importance of qualitative factors in biological analysis, there is thus nothing miraculous in Mendelian phenomena, but they must be considered as incidental upon the operations of symbiogenesis and its obverse—retrogenesis or degeneration (Entartung!)

It is not a coincidence that Vilmorin, Klebs and Dr. Walker all use illustrations drawn from the sphere of human economics—“private property” of the organisms, “good” and “bad” species—they are compelled by the actualities of each case to use such economic phraseology though no such terms are provided as yet by orthodox biology.

We cannot be surprised that our present methods of indiscriminate breeding are ill calculated to produce constant races, seeing that these methods are so little in accordance with nature’s gradual bio-economic methods. Prof. Klebs seems to think that the prospects of producing new races by cultivation appear to be full of promise, provided we give up much prejudice regarding “favourable” nutrition (surfeit!), with which I heartily agree. “So long as the view is held that good nourishment, *i.e.*, a plentiful supply of water and of salts, constitutes the essential characteristic of garden-cultivation, we can scarcely conceive that new mutations can be thus produced!”

Evidently what is required is knowledge of the bio-economic adequacy of nutrition. Failing this knowledge, Prof. Klebs has to admit that the question as to the causes of

* Prof. Bateson suggests that the wild crab-apple contains inhibiting elements which the cultivated kinds have lost. I would simply say that the cultivated apple has become somewhat surfeited at the expense of symbiotics, whilst the crab has not.

heredity remains, fundamentally, as far from solution as it was in Darwin's day.

It has been found in some cases that, "In order to obtain Mendelian segregation, variations occurring in a race occupying the same geographical area must be crossed; but that when characters in geographically separate races are crossed, they blend," which again would seem to point to the fact that Mendelian phenomena are but part and parcel of the great qualitative genetic processes "the long protracted gestation" of nature. The analogy with the superiority of cross-fertilisation and cross-feeding over in-breeding and in-feeding must indeed here suggest itself. If fertilisation is subservient, as I hold, to productiveness and to organic integrity in general, we can see how for bio-economic (symbiogenetic) reasons greater effectiveness and greater stability are in the end obtained by the union of slightly but sufficiently differentiated units from different areas than by the union of very homogeneous ones from the same area. That Nature abhors perpetual in-feeding and perpetual in-breeding, that there exists a biological antagonism to stagnancy, is thus another way of stating the "instability of the homogeneous!"

Dr. Walker lays great stress on the fact that no two cells are ever exactly alike, and that variations have been present from the very first stage, "otherwise evolution would absolutely have been impossible. . . . Offspring must always vary from their parents, and offspring of the same parents from each other."

"For the origin of this property of varying we must therefore go back to the origin of life itself, and it seems a work of supererogation to invent theories as to the causes of variations during the later stages of evolution and to treat them as if they had not been there all along."

The tendency to vary, then, is as old as the hills; and so, let us remember, is the economic problem, and so also the need of specialisation, of reciprocal differentiation, *i.e.*, of symbiogenesis if organisation is to be produced, to survive and to

evolve further. "Kein Lebend'ges ist ein Eins; immer ist's ein Vieles." Some parts are bound to be affected by a change. Hence results constant variation. But this does not do away with the need of explaining the directions.

Dr. Walker thinks that the variations occurring in the same locality are individual characters of recent origin, whilst differences between two geographically separate races which are common to all the individuals of the same race, are racial characters and are comparatively ancient.

In any case, however, if a true blend is to take place there has first to be a sufficient degree of compatibility, and this depends on the bio-economic adequacy of the union. Surely the fact that "characters" are ancient is not enough in itself to produce a perfect blend, although the fact that under certain circumstances they can blend well indicates that they have taken long reciprocal effort to evolve.

That crosses between individuals belonging to different species and even to different genera of fishes, as under the *Salmonidæ*, frequently produce perfect blending, may be but on a par with the case of convergence. If there be physiological and consequent anatomical convergence between members of different genera there may also occur instances of blending in fertilisation. The necessary compatibility frequently enough will be retrogressively achieved.

Dr. Walker thinks that many variations round the mean of any character must be useless and some "actually injurious," whence it would follow that the rapid elimination of useless variations is of great importance. This rapidity of elimination he supposes is provided for by the alternative inheritance of recent variations.

This again raises the question of biological usefulness, which, as we have seen, is determined by bio-economic considerations. Variations fail to produce a genuine blend, or are wholly incompatible, if the bio-economic antagonism between them has become extreme, *i.e.*, if they tend in opposite bio-economic directions, in that of strenuous or indolent

life, or if all alike have become impoverished because tending in the anti-biotic direction. It is difficult to see, apart from this, how any of them can be "actually injurious," although Darwin thinks that "we may feel sure that any variation in the least degree injurious would be rigidly destroyed" (by natural selection).

Prof. G. Henslow absolutely denies that Nature develops seedlings with any "injurious," *i.e.*, "inadaptive," variations (according to Darwin's requirement).

As we have recognised that there occur frequent compatibilities of unions of a retrogressive order, we must again conclude that what genuine genetic antagonism is exhibited by certain variations round the mean of a "character" is due to opposite bio-economic tendencies, which, of course, express themselves also in opposite physiological tendencies—and that a reliable standard of utility or of "injuriousness" can be obtained only on bio-economic lines.

We have also recognised that the fertilisation process itself is to some extent a safeguard against impurities and impedimenta, although even its good offices, like those of digestion, may become obliterated by abuse.

That Mendelian segregation constitutes a third line of defence, as it were, of racial purity is quite possible. It is essential for bio-economic reasons that the relatively higher and more valuable variations assert themselves against the relatively lower and less valuable (which, as we have seen, may easily have become the carriers of disease).

Before there can be any alternative inheritance at all, be it remembered, there must be a previous *evolution* of alternative "characters." Although, as Dr. Walker says, no two cells are ever precisely alike (which in Spencer's parlance makes variation co-extensive with heredity), their mere unlikeness affords no presumption of a fruitful or permanent and viable cross. Something more than this unlikeness is necessary, *viz.*, something complementary and mutually advantageous in their respective characteristics. It is this which gives the oppor-

tunity of reciprocal differentiation, and these special complements are nearly always the result of symbiotic processes.

For that which renders two important "characters" "alternative" is specialisation for mutual work, and in this light we can understand how the longer the process of mutual specialisation has taken to perfect itself, the more readily will the respective "characters" blend. We can thus understand how two "good" "characters" may join forces to produce physiological and general progress, *i.e.*, symbiogenesis. We can also understand how "characters" "previously independent of each other" may sometimes under new conditions associate in Nature or be artificially associated so long as at least some degree of bio-economic compatibility exists. There is generally at least some kind of racial and also of individual "property," some capacity for service in each case. But when accumulations of property have been reduced, when both domestic and biological symbiosis are resting on the slenderest foundations and service is becoming one-sided, or ceasing altogether, a permanent or progressive union becomes impossible. In all cases it is the qualitative and not the chronological factor that determines the result, that determines the degrees of physiological fertility or infertility.

That frequently in spite of a threefold line of defence—digestion, fertilisation and segregation of "characters"—pathological transmission actually takes place, and the pathological condition may persist for a long time, that "Mendelian" factors appear so frequently associated with pathological "characters," is further proof of the impossibility of dealing adequately with the phenomena here concerned with a mere chronological, or a mere quantitative and haphazard, instead of a proper qualitative method.

Dr. Walker also suggests that we have in certain constituents of the cell—the chromosomes—and the mode in which they are alternatively distributed to the gametes upon fertilisation, an exact parallel to the distribution of the characters in Mendelian inheritance, which in my opinion, particularly in

view of the metabolic connections, again indicates that in the last analysis we are here dealing with qualitative processes of an economic order (distribution!) with which we must assume the fertilisation process to be largely concerned.

As was pointed out by Dr. Doncaster in *Nature* (16/4/14): "Cytological Aspects of Heredity would seem to afford strong support to the view that the chromosomes play a very important part in the transmission of Mendelian characters (although the part played by the cytoplasm must also be taken into account)." With regard to sex-determination, with which Dr. Doncaster is particularly concerned, he says that difficulties arise in connection with the fact that this has been shown in certain cases to be modifiable by environmental conditions, and "it therefore appears probable that the sex chromosome is associated with a particular type of cell-metabolism, which in turn is responsible for sex-determination."

It is clear that the metabolism of the sex chromosome is largely determined by the general metabolism of the species, and this in turn by the bio-economic functions of the species. Hence we see again that the generic metabolism of the organism is a very responsible determinant of (chromosome) value and chromosome behaviour, and hence also of the evolution of sex generally. The connection between Mendelian phenomena and bio-economic factors thus also becomes once more emphatic.

Dr. Walker is willing with some modifications to concede the claim that the sex "character" behaves as a Mendelian factor. But we see now that it is more profoundly true that Mendelian characters behave like sex characters, *i.e.*, they either make or mar the zygote according to the bio-economic adequacy of the union. Alternative "characters," including sex, either stand in genuine reciprocal relation to each other and thus enrich the species by their union, or under retrograde (metabolic) compatibilities they produce unions which end with an impoverishment of the

species, with one-sided sex-determination (female preponderance, parthenogenesis, etc.), and frequently with extinction. Mendelian segregation may frequently be no more than the expression of incompatibility, of mutual (physiological) infertility, under certain circumstances. It may thus be a means of progress, in the same way as the poisonous effect of pollen on the stigma sometimes amounts to mutual infertility and prevents in and in-breeding, and stimulates instead cross-fertilisation, which is beneficial. Whether segregation is thus to subserve mutual infertility—as a part of a continuous process, *i.e.*, the formation of distinct physiological species or not, depends on the conditions of life.

Mendelian segregation thus seems to indicate the significance of the fertilisation process.

Prof. Bateson, who as the leader of the Cambridge School of Genetics has done so much to develop Mendelian ideas, states that it seems surprising that a feature apparently so fundamental as sex, *i.e.*, reproductive activity, should be differently constituted in different animals.

The simple explanation is that the differences of sex life are constituted in accordance with a factor that may easily be seen to make for differentiation generally, *i.e.*, bio-economic specialisation, as we have seen in the case of sexual symbiosis in plantagens, particularly in that of the lichen, and as we shall presently see in the case of cross- versus self-fertilisation.

“In the case of Variations generally,” says Dr. Walker, “which are of sufficient advantage to the race to be preserved by Selection, the alternative inheritance disappears in time and the character becomes racial.”

This, of course, may mean anything. “Selection” is a very convenient word. We have seen that in pathological cases—some of which have a wide distribution—a very “bad” variation becomes fixed and drives out a “good” variation, much in the same way as bad currency in human politics drives out good currency. This is indeed the great danger of all organic life, that it allows of pathological as well as healthy

transmission. Yet "Selection" is supposed at once rigidly to destroy all injurious variations!

"But the advantage of the differentiation of individuals in two sexes is dependent upon the alternative occurrence of particular characters." Precisely. It is dependent on the previous establishment or evolution of values in general and of reciprocal values in particular; and, as I have said, every new value is in a certain sense an alternative to an old value. The more values the more need of specialisation. Also, the higher the forms of specialisation (provided always a symbiogenesis is maintained and is gaining over retrogression), the greater becomes the aggregate output of values. The arrival of genius is largely due to the reciprocities of sex—"das ewig weibliche zieht uns hinan"—and it means a new dispensation in the biological sphere as well as in the human.

Certain it is that nothing is more detrimental to the "occurrence" (production) of highly specialised alternative sex "characters," as also to the production of values generally, than cessation of work.

And thus we see that with the explanation of symbiogenesis and with a proper qualitative analysis, genetic problems are not so terribly puzzling as is generally represented. Prof. Bateson states that:—

By following up the evidence as to segregation, indications have been obtained which can only be interpreted as meaning that when many factors are being simultaneously redistributed among the germ-cells, certain of them exert what must be described as a repulsion upon other factors,

and that we cannot surmise whither this discovery may lead us. We must urge that the explanation lies in "values," in the fact of attractions, distributions, re-arrangements and substitutions according to values and also of an antagonism which—for clearly recognisable bio-economic reasons—must always exist between the biologically good and the bad, and to a lesser extent between the good and the better. So far, without this explanation, the phenomena seem to indicate "chance," and

it has been customary hitherto to speak of "chance" variations. Truly "chance" here is nothing but the perceptible effect of a cause too complex and too remote for the ordinary specialist to have noticed.* One reason why some biologists almost resent the introduction of values seems to be the same as that which makes some physiologists insist so strenuously on the validity and self-sufficiency of the laws of Physics and Chemistry, viz., as Sir Oliver Lodge told us at Birmingham (British Association Presidential address), that they are keen to do their proper (specialist's) work.

We may view Evolution with Prof. Bateson as a process of "Variation and Heredity," but what began the process (omitted by Prof. Bateson), was the creation of first organic

* Since I wrote this, Prof. Bateson's address before the British Association in Melbourne has appeared in print. He tells us: "What these elements or *factors*, as we call them, are we do not know. That they are in some way directly transmitted by the material of the ovum and of the spermatozoon is obvious, but it seems to me unlikely that they are in any simple or literal sense material particles. I suspect that their properties depend on some phenomenon of arrangement. However that may be, analytical breeding proves that it is according to the distribution of these genetic factors, to use a non-committal term, that the characters of the offspring are decided." What with non-material particles, with phenomena of arrangement and of "distribution," with occasional loss of altruistic (i.e., symbiogenetic) instincts (as in the case of the leghorn where the absence of the maternal instinct is "due to loss of one factor which the jungle-fowl possesses") associated with loss of "Mendelian" factor, the reader will observe that it is not a far cry to purely economic causes (factors) and that the bio-economic and symbiogenetic explanation that I have supplied must at least prove suggestive. Prof. Bateson goes so far as to say that the available evidence points to the conclusion that even the differences which characterise distinct species are due to such factors, which on my interpretation means to say that evolution proceeds on bio-economically pre-determined lines. As regards the postulate of the "Ur-organismus," Prof. Bateson states: "At first it may seem rank absurdity to suppose that the primordial form or forms of protoplasm could have contained complexity enough to produce the divers types of life. But is it easier to imagine that these powers could have been conveyed by extrinsic additions? of what nature could these additions be?" Whilst willing to concede the absurdity of the Mendelian proposition regarding the "Ur-organism," my answer to Prof. Bateson's queries is that the complex powers of protoplasm have been gradually evolved through symbiogenesis, i.e., through progressive symbiotic (bio-economic, bio-dynamic and bio-chemical) transmutation of values, involving at the same time an ever-increasing complexity of relatedness. In other words physiological capital so evolved was primitive. Its subsequent use to similar and other purposes caused an increasing complexity of forms. Whilst, therefore, agreeing with Prof. Bateson that *primarily* "that which is conferred in variation must rather itself be a change, not of material, but of arrangement, or of motion," (i.e., a bio-dynamic change, as I would say) we need not reject all "extrinsic additions" (some of which, as we have seen, must be regarded as symbiogenetic agents) as summarily as he does when he continues: "The invocation of additions extrinsic to the organism does not seriously help us to imagine how the power to change can be conferred, and if it proves that hope in that direction must be abandoned, I think we lose very little." I believe I have sufficiently shown, that without the recognition of extrinsic symbiogenetic additions and their true value, the study of Genetics in particular must be well-nigh futile. Prof. Bateson suggests abandonment of the richest vein of inquiry almost in the same breath in which he disconsolately admits the utmost uncertainty as regards discrimination of the value of "factors."

wealth by "doing well" (work), and what continued it was the subsequent "doing, better, best" which under many fluctuations led to varying hereditary and genetic phenomena and to varying degrees of compatibility. The main theme—the "leitmotif"—was symbiogenesis, the rest only "variations" of that theme.

With such provisos we will accept Prof. Bateson's statement that Genetic Variation is primarily the consequence of additions to, or omissions from, the stock of elements which the species contains. I should simply say that the fact that a species has become richer or poorer in values expresses itself in commensurate variations whether in numbers or quality.

Prof. Bateson also states ("Heredity and Variation in Modern Lights," contributed to "Darwin and Modern Science") that the greatest advance that we can foresee will be made when it is found possible to connect the geometrical phenomena of development with the chemical. "The geometrical symmetry of living organisms is the key to a knowledge of their regularity, of the forces which cause it."

On the importance of this factor of symmetry, Prof. Bateson has indeed long insisted. I have likewise now for some twenty years been considering the biological significance of symmetry and of proportion in Nature. My conclusion is that important principles of normality, *i.e.*, of cosmic utility (character), permitting of adequate and unimpeded mutual serviceableness and of reliable and world-wide reciprocal differentiation, are involved in what we call the felicity, the chaste austerity, purity and beauty of natural forms. I have spoken of the biological law of definite proportions in this connection, on the analogy to the similar chemical law. A physical analogy exists even as regards impurities. The presence of such in each case results in a combination and aggravation of the injurious "morphogenetic" effects of such. Cessation of work is universally followed by loss of symmetry and of proportion, and I have connected the phenomenon with

lack of physiological balance due to abnormal, *i.e.*, anti-biotic, propensities with the subsequent advent of impurities.

“Others in virtue plac’d felicity.”

Pathology constantly illustrates Physiology, and just as I hold that parasitism and anti-biotic habits generally make for loss of proportion and asymmetry, so I consider symmetry primarily as the expression of a well-balanced moving equilibrium—well-balanced, that is domestically and biologically. We have seen the intimate connection between chemical and bio-economic (symbiotic) factors, and thus it is not a far cry to their connection with mathematical and geometrical phenomena.

Symmetry and proportion depend on wholesome and harmonious distribution of materials in a living system, and this, in turn, on a series of steady, wholesome and reliable efforts, producing the right kind of external stimulation and of circulation. As all this involves, as we have seen, proper bio-economic activity—proper give and take, proper domestic and biological symbiosis, proper restraint, proper sympathy—we may also say that symmetry and proportion are a matter of harmonious adjustment to the biological environment.

We have seen that circulation—and, according to Dr. A. Haig, “Life is Circulation”—and “full-bloodedness” depend on biological symbiosis, nay more, that animal flesh is for its very existence dependent on perpetual work, *i.e.*, primarily on the photosynthetic work of the green plant as the first beat of a rhythm, and, further, that the progress of all flesh depends in turn on the animal’s own bio-economic service-ability, the secondary (harmonious) beat or return of the rhythm. To be symmetrical and well-proportioned is thus to be in tune with the (biological) world, *i.e.*, with the universe, and the path to that goal is work.

In his volume on *Organic Evolution*, Prof. Eimer attempts to explain the famous statue of Apollo Sauroktonos by means of a lizard-catching “industry” widely spread in Italy. The beautiful and symmetrical figure, he thinks, is that of a boy

who is snaring a lizard with a noose of grass. "The meaning is only comprehensible on this explanation, and with it the work appears in all its life-like truth and harmony."

True beauty, *i.e.*, the truth of form which we call beauty, which I consider antithetic to monstrosity or deformity, is generally at home amongst the industrious and connected with wholesome industry. It does not, of course, depend on any particular industry, but rather on the whole attitude to life of a race generally. The question of beauty as resulting from proper activities becomes a national matter, as has been well perceived by those anxious to raise the level of the community, by those who are "das Land der Griechen mit der Seele suchend."

The art of predaceous nations, according to Ruskin, represents living creatures "under some distorted and monstrous form," and this is what it means to him:—

It thus indicates that the people who practise it are cut off from all private sources of healthy knowledge or natural delight; that they have wilfully sealed up and put aside the entire volume of the world, and have got nothing to read, nothing to dwell upon but that imagination of the thoughts of their hearts, of which we are told that "it is only evil continually."

When Art is occupied in the function in which she is serviceable, she is herself strengthened by the service, according to Ruskin, and the same must be said of all organic form. Let us bear in mind also the need of restraint in symmetry and in good art generally, as Ruskin tells us:—

But the last phase of good Gothic has no room to spare: it rises as high as it can on narrowest foundation, stands in perfect strength with the least possible substance in its bars, connects niche with niche and line with line in an exquisite harmony, from which no stone can be removed and to which you can add not a pinnacle; and yet introduces in rich, though now more calculated profusion, the living element of its sculpture—sculpture in the quartrefoils, sculpture in the brackets, sculpture in the gargoyles, sculpture in the niches, sculpture in the ridges and hollows of its mouldings—not a shadow without meaning, and not a light without life.

L'arte pura è magra.

We need only put "species" for "nations" and we see that the same factors that make for loss of beauty within a nation, also make for loss of symmetry in a species. Shakespeare, in referring to the desolation caused by war, tells us in other words how cessation of genuine bio-economic activity in the web of life is incompatible with beauty and utility (which are inter-dependent):—

The even mead, that erst brought sweetly forth
The freckled cowslip, burnet, and green clover,
Wanting the scythe, all uncorrected, rank,
Conceives by idleness; and nothing teems
But hateful docks, rough thistles, kecksies, burs,
Losing both beauty and utility.

Darwin showed by his classical experiments that continued self-fertilisation in plants tends to the production of "somewhat monstrous" forms, and we must conclude that self-fertilisation is responsible for such teratological (pathological) development, precisely because this mode of fertilisation is bio-economically speaking inferior and antagonised by the tendency towards cross-fertilisation, which is associated with higher, *i.e.*, better organised life functions of the plant and with the maintenance and progress of biological industries generally. If plants are artificially deprived of their highest industry, they must lose the felicity of form that was once connected with it. If there were not the bio-economic need of cross-fertilisation, as I have depicted it, it is safe to say it would not have arisen at all, and there would have been no such striking antagonism between the cross-fertilising and self-fertilising modes as we find, especially since the former on any other explanation would appear to be wasteful rather than useful. As Darwin says: "A very small quantity of pollen would have been sufficient for fertilisation (self-fertilisation) instead of millions of grains being produced" (cross-fertilisation). Thus again we have the connection between true usefulness and truth of form (normality), as between sexual and bio-economic differentiation. The very fact that symmetry and proportion impress us as

beautiful is because we get the impression of utility, goodness, wholesomeness, moderation, and harmony generally. According to Aristotle, there is more both of beauty and of *raison d'être* in the works of nature than in those of art. It is in large measure this *raison d'être*, I hold, which constitutes the beauty and symmetry of natural things. It is thus more than a mere coincidence that the words symmetry, symbiosis and sympathy show an etymological connection.

It is generally but falsely represented that reproduction constitutes the chief *raison d'être* of organisms. But it is work and service rather than redundancy that the world demands from every race. To be is to be active, and this in a social sense. Reproduction unless morbidly distorted is likewise subordinate to this demand, and really assists in the segregation of that which is most valuable in a race from that which is becoming relatively inferior. If the bio-economic contribution of a species be steady and important, if it take a conspicuous share in determining the world—in leaving it the richer rather than the poorer for its presence—it sets up wholesome and balancing reactions by which it in turn benefits. As a consequence of such mutual determination, a species bears the stamp of balance and of symmetry—of beauty that is more than skin-deep. It is very significant that the higher we rise in the animal scale the less evidence there is of antithesis of size, *i.e.*, of sexual dimorphism, of metamorphosis, partial dissimilarity of offspring and of redundancy. On the other hand, depredation, by causing a distorted and unreliable supply of impure blood, from which results abnormality of growth, leads to distortion of form and size. Everywhere parasitism and distortion of form are closely associated and strikingly and obviously mark a movement along the path that leads to extinction. “Everywhere,” says Dr. Woods Hutchinson, “the habitual murderers, the professional assassins and liers-in-wait, like the alligator, the rattlesnake, the puff-adder, and the shark, bear the brand of Cain on every inch of their surface—in their dull, muddy, blotchy colours,

uncouth or hideous shapes, and general repulsiveness of appearance." Hence it is that, inversely, beauty and symmetry are indications that the central authority of an organism is well maintained *pari passu* with its bio-economic integrity, and hence also we see again that all development of form depends on the total adjustment or compromise which a species is able to effect with the world at large.

Prof. Bateson also tells us that:—

If we had to choose some one piece of more proximate knowledge which we would more especially like to acquire, I suppose we should ask for the secret of interracial sterility. Nothing has yet been discovered to remove the grave difficulty, by which Huxley in particular was so much oppressed, that among the many varieties produced under domestication—which we all regard as analogous to the species seen in nature—no clear case of interracial sterility has been demonstrated. The phenomenon is probably the only one to which the domesticated products seem to afford no parallel. No solution of the difficulty can be offered which has positive value, but it is perhaps worth considering the facts in the light of modern ideas. It should be observed that we are not discussing incompatibility of two species to produce offspring (a totally distinct phenomenon), but the sterility of the offspring which many of them do produce.

Now, what may be the cause of sterility? Physiological, anatomical, psychological! View it as we may, we are driven back in the last analysis upon the bio-economic cause. The cause is the same as that which produces asymmetry, extreme dimorphism and extinction in nature, namely, the loss of symbiotics and the various forms and degrees of biological antagonism arising from this loss.

That there must be a kind of "progressive" incompatibility between different species is explainable, as we have seen, on bio-economic grounds, and so is the usual sterility of hybrids precariously produced, *i.e.*, under a retrograde compatibility, lending itself perhaps to reproduction, but less so to stability.

That there are instances of retrograde compatibility in biological unions, we have seen from the example of *Convolvata*, and that there are instances of "fertility" retrogressively

achieved is also abundantly shown in nature. Redundancy itself I consider to be due to degeneration. It is known that some plants are highly self-fertile (*i.e.*, redundant) when insects are excluded, others are not.

Ipomea purpurea was one of the highly self-fertile species in Darwin's experiments, and here he found a (retrograde) self-fertilisation so great (and apparently so successful) that he termed one seedling "Hero." "Hero" appeared in the sixth self-fertilised generation and "exceeded by a little in height its inter-crossed opponent—a case which had not occurred in any previous generation." "Hero" was able to transmit its increased tallness and a high degree of self-fertility to its offspring.

Generally speaking, however, in Darwin's experiments, the advantage of vigour and of health lay with the cross-fertilised plants, and as the argument from mere bulk and mere numbers is by no means convincing as to real or permanent success, and as even these carefully planned experiments must needs have been somewhat artificial—seeing that bio-economic correspondences were but inadequately taken into account—we may be sure that an exceptional case of apparently successful self-fertilisation represents a retrograde compatibility—always a contingency under tempting conditions of surfeit or its equivalent, and particularly so with plants already inclined to be self-fertile, *i.e.*, less reliant than others on biological symbiosis. To obtain an expedient (domestic) gain at the expense of biological (communal) integrity is always a possibility; but in reality it amounts to a retrogression and finally to a loss for the species. If several organisms similarly inclined unite, be it economically or genetically, they do so under what I call a retrograde compatibility, and the result is a pathogenesis.

In *Nutrition and Evolution* I have already pointed out that "apparent" incongruities were bound to arise, and this naturally misled Darwin, and almost made him doubt the truth of his great generalisation concerning cross-fertilisation, since

he shared the common prejudice regarding "good nourishment."

In the case of the dimorphic cowslip, Darwin says the increasing fertility in successive generations after what he terms "illegitimate fertilisations" was such that it seemed as if they were becoming "habituated to it," *i.e.*, as I would say, an inferior habit—under a retrograde compatibility—established itself, and the apparent "success" is only that of retrogenesis (*i.e.*, the quasi-fertility is as illegitimate as the mode of fertilisation).

But do types retrogressively arising really deserve the name of "Hero"? Does the term not apply more aptly to cases of self-sterility which we have already viewed as a means of checking an abhorred self-fertilisation? Darwin tells us that self-sterility runs to a certain extent in groups, and that it differs much in degrees in different plants. In those extraordinary cases in which pollen from the same flower acts on the stigma like a poison, "it is almost certain," he says, "that the plants would never yield a single self-fertilised seed." This resistance to degenerative influences—this striking antagonism of a bio-economically useful and superior to a relatively wasteful and inferior behaviour—seems to be nearer the source of heroism and honour than a yielding to the temptation of unproductive self-fertilisation.

Dies Leben ist der Güter höchstes nicht,
Der Übel grösstes aber, ist die Schuld.

Orchids are among the most unproductive of plants, and some varieties existing in Nature, such as *Ophrys apifera*, regularly fertilise themselves. The same must be said of certain cleistogamic plants, which produce an abundance of cleistogamic flowers, "but are very rarely capable of cross-fertilisation."

Most species of orchids in the equatorial regions live as epiphytes or parasites on living or dead vegetables. Their "heroism" is of a very questionable kind.

Prof. Bateson further tells us that though all our finches can breed together, the hybrids are all sterile; and that among ducks some species can breed together without possessing the slightest sterility, others have totally sterile offspring, and so on.

In all these instances we have varying degrees of domestication and of induced diathesis which must present a variety of metabolic fluctuations, and, hence, frequent opportunities for the most varying compatibilities, though not necessarily for genuine genetic results.

It is known that some finches require special "love-foods" (grains) for the production of song, and a progressive in-fertility may thus arise in connection with high æsthetic specialisation alone and the keen discrimination of food that it requires. Ducks, which are far more over-domesticated and also far less engaged in higher kinds of specialisation than finches, may be seen to be far more prone to retrograde fertility.

That the hybrids produced by the Turnip (*Brassica napus*) and the Swede (*Brassica campestris*) are totally sterile is also explainable as arising from over-cultivation, with resultant loss of symbiotics. That they are allied forms does not necessarily imply that their offspring when crossed becomes really "viable." The two strains of the one form when crossed (as in the case of the "rusty" crossed with the healthy wheat) may produce a decided lowering of the resultant, and must thus render heredity—which may already have been on its last legs as it were—increasingly difficult. This case, therefore, is a confirmation of my remarks on the subject of the *misère* of cultivated wheat and the apparent "dominance" of the diseased condition. The expensiveness of the processes of fertilisation and reproduction also has to be taken into account. The cultivated turnip is known to be particularly liable to the attacks of the troublesome *Heterodera*. The turnip's condition must, therefore, be understood to be pathological and lacking in resistance. In the desert the relation between plant and *Nematode* is symbiotic and therefore wholesome, and if under

conditions of cultivation this relation turns anti-biotic and pathological, this, I submit, indicates that a loss of symbiotics and of general vitality and resisting power go together.

“Lastly, it may be recalled,” says Prof. Bateson, “that in sterility we are almost certainly considering a meristic phenomenon. Failure to divide is, we may feel fairly certain, the immediate ‘cause’ of the sterility.”

But failure to “divide” is failure in producing an adequate symbiotic *élan* due to failure of bio-chemical stimulation, and this, in turn, is due to a distortion of biological symbiosis. There is an insufficiency of symbiotic momentum.

Prof. Bateson thinks we are justified in presuming that there are factors which can arrest or prevent cell-division. Precisely. There are. Many factors, as we have seen, must co-operate to produce adequate stimulation of so complex a mechanism as that involved in the fertilisation of highly symbiotic organisms. The weakening of any one of these factors must certainly seriously interfere with proper cell-division, just as it would also interfere with, let us say, the proper functioning of the *corpus luteum* or its equivalent in the lower orders.

The same causes that produce the manifold phenomena of nemesis of reproduction and stimulate vegetative growth at the expense of sexual development, must also in the long run produce disturbances of cell-division, which may become pronounced at any moment and inhibit further division.

Prof. Bateson endorses the statement of Samuel Butler: “To me it appears that the ‘origin of variation,’ whatever it is, is the only true ‘origin of species,’” which I also fully endorse, although I do not share Prof. Bateson’s belief that the origin of variation is so very mysterious.

In his address at Melbourne as President of the British Association, Prof. Bateson made the statement that we cannot even imagine any changes in progress around us in the contemporary world likely to culminate in the evolution of forms distinct in the larger sense (species as distinct from variations).

“Whether science will hereafter discover (a discovery which, he says, he anticipates, without being able to defend the opinion with positive conviction) that certain groups can by peculiarities in their genetic *physiology* be declared to have a *prerogative quality* justifying their recognition as species in the old sense, and that the differences of others are of such a subordinate degree that they may in contrast be termed varieties, further genetic research alone can show.” (Italics mine.) The anticipation here expressed by the eminent biologist can only allude to the discovery of values, such as I have attempted to formulate on my theory of symbiogenesis. What remained to be discovered was, precisely, the principle underlying qualification (qualification that is in an evolutionary sense). Obviously before we can duly determine and classify the peculiarities of genetic physiology, we must first have a clear recognition of the beginnings, foundations and leading principles (including nutritional “amphimixis”) of genetic physiology, and this, as we have realised, necessitates many a step outside the province of (what is generally considered as) pure genetics, and involves inquiries into those very bio-economic regions which Prof. Bateson would fain see abandoned as bare of any yields. It involves the recognition of that “little more and how much it is” which Prof. Bateson would fain condemn. The “little less” in these important matters leads, in the case of Darwinism, almost to an absolute denial of progress, of ethical continuity, of values, of status, and of every form of design in Nature—a kind of chaos. “Too often in the past the facile formulas of natural selection have been made use of to carry us lightly over the surface of unsuspected depths that would richly have repaid serious exploration” (Prof. E. B. Wilson). It leads, in the case of Mendelism, as we have seen, to an inverted evolutionary outlook as illustrated by the postulate of the “Ur-organismus,” the original and perfect “hold-all” of all qualities. Rightly, so it appears to me, Prof. E. B. Wilson (Pres. Address, Zoology, Americ. Assoc., 1914) demurs to the Mendelian inver-

sion and to its paradoxical consequences in regard to the nature of evolution: "Are we prepared to stake so much upon the correctness of a single hypothesis of allelomorphism and dominance"? Are we not invited "to strain at a gnat and to swallow a camel"? Nevertheless, in our turn, we will by no means under-rate the value of genetic research, and we hope with Prof. Bateson that it will contribute an appreciable quota towards an ampler theory of evolution than is provided by the older schemes which he, for one, will no longer accept as gospel.

CHAPTER IV.

BIONOMICS.

All beautiful lines are drawn under mathematical laws organically *transgressed*.—RUSKIN.

The approximateness reveals the *endeavour*, which arouses our sympathy, while mathematical exactness leaves us dull.—Perhaps the logarithmic spiral with the Pheidias ratio is an “objective” element in beauty.—We like Mr. Schooling’s suggestion that the Pheidias proportion is an expression of economy of form.—*Nature*, No. 2359, Vol. 94.

Beauty and growth are visibly expressed to us in terms of the same fundamental principles.—TH. ANDREW COOK, M.A., F.S.A.

If the law of the square is the law of attraction, the law of the cube (that is, of the cell) is the law of production and the logarithmic spiral is a manifestation of the law which is at work in the increase and growth of organic bodies.—PROF. GOODSIR.

La division du travail ne servirait à rien sans la symbiose.—

GIGLIO-TOS.

Ce n’est pas le tout de survivre : la *manière* a son importance.

La faim et l’amour, disait Schiller, sont les deux forces motrices du monde. Mais il faut ajouter qu’elles ne poussent pas les êtres dans la même direction ; si la faim les sépare, l’amour les rapproche (C’est la pensée que commenta Kessler, dans une communication faite au congrès des naturalistes russes (1880) et qui suggéra les recherches de Kropotkine). . . .

Hodgskin l’objectait il y a longtemps au pessimisme malthusien : bien plus que l’étendue superficielle du sol, c’est le travail et le savoir qui produisent les aliments. . . .

La loi de Darwin n’est que la loi de Malthus généralisée. . .

Et ce qui se dégage de plus net de notre recherche sur les leçons de la biologie, c’est l’extrême difficulté où est l’homme de “laisser parler la nature” pour enregistrer son conseil : la conseillère parle plusieurs langages, et varie ses réponses suivant les idées préconçues des enquêteurs. . . . C. BOUGLÉ.

It has already become abundantly evident that with Bio-Economics, Bio-Dynamics, and Symbiogenesis we have

introduced conceptions which must go a long way to modify and to complement not only the various theories of evolution now extant, but also the "Principles of Biology" as they have hitherto been recognised.

It was Herbert Spencer's great merit clearly to formulate these principles in accordance with the scientific knowledge and general philosophical views of his time. His comprehensive survey filled a great need. It proved useful as a fruitful source of suggestion, and complemented the great work of the Victorian period with which his name, as well as that of Darwin, will always remain prominently associated.

A detailed consideration of his biological "principles" will provide the best opportunity of showing how the new principles of Bio-Economics for which I contend require to be systematically applied to Biology.

A

In his first chapter on "Organic Matter," Spencer tells us:—

The properties of substances, though destroyed to sense by combination, are not destroyed in reality: it follows from the persistence of force, that the properties of a compound are *resultants* of the properties of its components—*resultants* in which the properties of the components are severally in full action, though greatly obscured by each other. One of the leading properties of each substance is its degree of molecular mobility; and its degree of molecular mobility more or less sensibly affects the molecular mobilities of the various compounds into which it enters.

The argument, as we see, is drawn from fundamentals; the "persistence of force" to Spencer was only a better term for the "conservation of energy," and "force" itself one of his "unknowables." Notwithstanding the mystery of "force," it is to this dynamic conception of organic matter as the most adequate for practical purposes that we must attach special importance. True, it has been found to be overlaid with more complexity than Spencer knew of. Yet what Prof. Bateson says of Darwin, viz., that we must be thankful that he made his sweeping though premature pronouncement as regards the factors of evolution, holds also, I believe, of many

of Herbert Spencer's pronouncements anent the Principles of Biology. We have seen already how modern experimental Biology is driven to go back to the dynamic concepts of Spencer, and how these will have to be developed into a proper science of Bio-Dynamics. We have also seen that his views are too mechanical, and that he exaggerates the passivity of life. It sounds like a protest against and a correction of Spencer's view when we find Prof. Bateson declaring "The bodies and properties of living things are cosmic, not chaotic." But this modern view has reference only to the Mendelian concept of the constitution of organic matter, and though this view and the connected chemical factors were unknown to Spencer, we have found that they resolve themselves in the last analysis into bio-dynamic, *i.e.*, bio-economic, factors. Although, therefore, the "reign of law" has become more complex and more emphatic since the days of Newton, Darwin, Spencer, and the Duke of Argyll, yet dynamics still provide the best clue to the understanding of the phenomena of life.

There is an "all-pervading orderliness," says Prof. Bateson, "nor can we conceive of an organism existing for one moment in any other state." It should be added, however, that all organisms are bio-dynamically inter-related, and that this is the very cause of that orderliness of chemical and genetic units which compares so strikingly with that of cosmic bodies and invites the suggestion of "cosmic" properties in organic matter.

We have already seen that even this Batesonian recognition of "cosmic" law and of an "all-pervading orderliness" had to remain vague pending the introduction of Bio-Economics and Bio-Dynamics. In the absence of "values" what elementary mechanics could be applied had to be a kind of "theoretical" mechanics. "Applied" or "practical" dynamics require "values" which, however, have not been supplied hitherto.

Let us take another modern pronouncement bearing on the dynamics of life by a leading Biologist:—

“We know now that the problem of the process of cell-growth and cell-nutrition is not one which we have at present any prospect of solving in a mechanistic direction,” says Dr. J. S. Haldane.

Again we see—now from other considerations—that the Spencerian conceptions as they stand fail to give satisfaction to the modern mind. Newtonian dynamics are fundamental and all-pervading, but they are nevertheless insufficient for the purpose of modern Biology unless supplemented by biological considerations. Instead of reducing the body to mechanics, we must, as Samuel Butler says, “raise the mechanism to the body.” Just as in Philosophy the new school is trying to invert metaphysics, and beginning with personality to work outwards, so in Biology we must invert its old methods and beginning with action try to understand the resulting forms. “Im Anfang war die That.” The dynamics of biological activities and relatedness must be considered, as well as the simpler molar and molecular dynamics.

I claim that the bio-economics and bio-dynamic theory which I have set forth represents, above all, common sense. In every-day life, as well as in national life, when it is found incumbent on us as citizens to give serious attention to “Economics,” this is generally a symptom of common sense. One of our statesmen has recently reminded us that Finance is second in importance only to Religion. This applies to National Economy; but it may be that even as regards Bio-Economics more thoughtful future generations will be as studious to set themselves right with the universe economically as past generations have been anxious to be square with the Lord theologically. It has indeed been said: “Seek ye first the Kingdom of God and His righteousness and all these things shall be added unto you,” but a searcher is ill-advised if he thinks he can afford to neglect the path of bio-economic rectitude which is one part of that righteousness. “Peut-être les sociétés futures réproveront-elles énergiquement les pratiques économiques que nous laissons passer aujourd’hui,”

says Bouglé; and the same may be said as regards bio-economic (physiological) practices which must always largely determine social practices, and in the long run, I hold, the very "esprit social."

Science, according to Butler, is too young to know what common sense is. This, I submit, is now to be remedied, in one direction at least, by the study of Bio-Economics. When the same astute writer goes on to say: "As soon as the world began to busy itself with evolution it said good-bye to common sense, and must get on with uncommon sense as best it can," this gibe is not altogether unwarranted, chiefly again because in the first flush of victory the new-fangled beliefs and dogmas ignored values or at best only very partially recognised Economics as concerned at all.*

Both the Batesonian view concerning the "cosmic" and "non-chaotic" properties, and the "all-pervading orderliness" of living things and the Haldanian view of an eventual "non-mechanistic" solution of the principal problems of life, I claim, find their true place in the system of Bio-Economics and in that theory of co-operative evolution (symbiogenesis) for which I contend. In my *Evolution by Co-operation*, I have already set it forth that the parts of an organism as well as the members of the biological world "must have a meaning for each other; they must have something to spare for and to exchange with each other. In short, organisation, *i.e.*, specialisation of function, implies co-operation, *i.e.*, social activity, and I therefore maintain that the relation of parts must approximate to the conditions of trade in the human community, where no member can more than temporarily suffer or rejoice by itself, and where an apparent advantage to one

* According to *The Times* (16/1/15) an inadequate perception of the things that belong to peace has in a sense justified the description of the present great war as a "terrible medicine" (Bernhardi). But now, "before the sudden and fiery blast of war there has been a noticeable repudiation of the respect paid in times of peace to artificial and inverted cults." By way of reaction it now appears that "commonplace views and copy-book virtues have made a new appeal to minds whose former craving for excitement and novelty is now so tragically satiated." An ignominious peace and a suppression or perversion of true mental and moral values are thus amongst the most potent causes of war.

gained through the misfortune of the other is only superficial."

To return to Spencer. He states, as quoted above, that the degree of molecular mobility of each substance more or less sensibly affects the molecular mobilities of the various compounds into which it enters. This is to say, in other words, that substances from a dynamical point of view affect a compound according to their character. In a similar way in Biology, every substance and every character affect the compound into which they enter according to their bio-dynamic value, *i.e.*, to the "work" to which they have become habituated. Evidence thereof will again be provided on subsequent pages. We use the term character because of its convenience. It tacitly implies (as soon as we come to think of it) mutual adaptation for work as has been pointed out. In the inorganic world already we meet with the curious fact of "isomerization"—difference of function, of habit, or of character, as we might say, in substances seemingly of one and the same material composition. There are, for instance, the so-called allotropic modifications of certain elements which show how the character of even so relatively fixed an entity as a chemical element may vary.

There is further to be considered here, as of the utmost importance in the evolution of life, a gradation of changes of a somewhat similar nature in the state of matter, the original study of which we owe to Thomas Graham, the founder of Collochemistry, *viz.*, from crystallinity to colloidity, and vice versa.

These changes, as we now know, are connected with changes of surface-tension: the same force which shapes the raindrop, in the opinion of Prof. A. B. Macallum and other Collochemists, being an all-important factor in the causation of vital phenomena.

Collochemists tell us that it is the colloidal substances, or rather, that remarkable phase of matter termed colloidity, which have been specialised as "privileged" carriers of

energy. Nevertheless, it must be borne in mind that what charges of energy a colloidal aggregate conveys, depends greatly on the "inner nature," *i.e.*, the character, *i.e.*, on the general use-relatedness in the world of life of the constituent elements.

If, in the case of colloids, the surface tension assumes a particular importance so as to impart special dynamic or "vital" properties to these bodies, not possessed by crystalloids, this may be partially explained as due to their past evolutionary (symbiogenetic) history, much as the powers of storing energy on the part of the plant were gradually and symbiogenetically evolved.

We have seen that in the case of plantagens, the phase of efflorescence of sex involves a more intense internal co-operative and also external symbiotic activity—a higher "symbiotic" potential as it were—than is required by the mere asexual phase; sex and its concomitant good effects thus representing the highest dynamic and symbiogenetic achievement of the plantagen community.

We have seen it to be similar in the case of the more purely bio-economic synthesis struck up by the lichen, where we found high symbiotic potential closely associated with high chemical and high electrical potentials, and also, again, with high forms of use-relatedness in the world of life. We also insisted that in every case the higher phase was led up to by adequate previous work and adequate "nutritional" amphimixis based upon adequate reciprocal differentiation.

We must assume that something similar takes place in the evolution of the elements which brings them eventually to the "colloidal" efflorescence.

Dr. H. Leiser indeed speaks, though, of course, somewhat figuratively, of the groups of peoples and of the clans and tribes inhabiting the colloidal world—of their peculiarities, conditions of existence, their external appearance, etc.; and von Zsigmondy, who was the first mortal to observe these "populations" by means of the ultramicroscope, tells us that

they represent a world of the utmost activity: "Das ist ein Hüpfen, Tanzen, Springen, ein Zusammenprallen and Voneinanderfliehen, dass man Mühe hat, sich in dem Gewirre zurechtzufinden." ("There are hopping, dancing, leaping, colliding and dispersing movements going on so that one has great difficulty in seeing one's way in the confusion.") All of which recalls biological phenomena, as does also the fact that the variations in the surface-tension of a cell (and, hence, in the output of work and, hence also, in evolution) depend on the nature of its inorganic associations (concentration of salts and minerals ingested at various positions in or near the surface).

A further analogy with (biological) symbiogenesis, or biological "alchemy," as we have seen it to be operative in cross-feeding and cross-fertilisation, is to be found in the world of colloids in the fact that frequently a transformation of crystalloid into colloid matter is achieved by a kind of "infection," viz., by the action of acids—"Anätzen," as the Germans call it. Another method of transformation, a direct imitation of the digestive "alchemy" of the human body, consists in "Peptisation"—viz., adding to a crystal certain salts, the so-called Sol-formers. The term "Peptisation" is indeed borrowed from the digestion of albumin in the stomach, where, as is well known, small traces of hydrochloric acid are capable of changing quantities of albumin into colloidal solutions, thus rendering them fit for further elaboration by the organism.

An explanation of the principle underlying the peptisation of crystals has not yet been put forward. On the lines of my symbiogenetic theory, however, and in view of the fact that special activities (work!) are *universally* manifested in the very act of change of state, I would suggest that in the evolution of the inorganic as of that of the organic world, a principle of reciprocal differentiation regulating all affinities has gradually sprung up—"holde Gewohnheit aus dem Keim der Bekanntschaft"—and that the resulting synthesis must

be regarded as due to a symbiogenetic process serving much the same purposes in the inorganic as in the organic world, viz., the amplification and the increase of the powers of life.

We must remember that the distinction between colloid and crystalloid cannot always be sharply drawn, and that it is thus not so very difficult to see in these two varying phases of matter the evolution of a wholesome antagonism, *i.e.*, a diversification, a mutual specialisation for the purposes of symbiogenesis: progressive synthesis in keeping with the new values ever arising in the world of life (in the widest sense of the word). Moreover, it is not all bodies that are capable of forming colloidal masses, which would again seem to indicate that this property depends on the previous evolution of definite affinities, such as those classed by me under the head of "reciprocal differentiation."

It is noteworthy in this connection to have Prof. H. E. Armstrong expressing the following view before the British Association in Australia: "The variable valency of certain elements is another difficulty; the variation seems to be determined by some *reciprocal relationship* between the *interacting* elements, valency being a *dependent variable* and not an *absolute* property." (Italics mine.)

In the light of these considerations, we may say that the character of a substance represents a kind of (variable) specialisation for work—frequently mutual, symbiotic and vicarious—a kind of individualisation participating in and subserving cosmic evolution.

Though we can still admit, broadly speaking, the truth of Spencer's contention that the properties of a compound are *resultants* of the properties of its components, we are now in a position to amplify it by stating that the properties of substances are the resultants of the charges of energy they convey, both on the surface and within, as a consequence of their structure and position, as well as in virtue of the past symbiogenetic evolution of their component elements.

We also have in the so-called catalysers: enzymes,

hormones and vitamines, substances which though present in but minute amounts, yet by their molecular constitution—their symbiogenetic character—are capable of producing most wonderful and most important effects upon organic matter. Nay, more, they seem to contain the most indispensable guiding principles influencing organic form. The absence of “vitamines” in food, as we have seen, is easily fatal because leading to “deficiency-diseases.” It is due to the presence, again, of adequate bio-chemical stimulation that such important glands as the *corpus luteum* and the thyroid are able to perform their vital and indispensable functions. The very word “bio-chemical” proclaims that life itself, in its efforts to solve the economic problem, we may presume, gives rise to these substances. They appear originally as bye-products of the photosynthetic and associated metabolic processes of the plant, which processes, just as they imply a storage of material for future bio-economic use, so also in a subtle way impress symbiogenetic momentum upon these highly complex and delicately poised substances. Bio-chemical substances are thus essentially bio-economic substances, and, like organs, owe their efficacy to symbiogenetic processes. Enzymes have been termed the tools of cells. Their number is legion; but Chemistry cannot produce them. They are found only as the products of protoplasm of living cells and are known only by their reactions—“by their works ye shall know them.” They are found in association with proteins. Mineral salts, however, seem essential for their action, which would seem to indicate the primordial connection with cross-feeding on the part of the strenuous vegetable or plant-animal cell.

In Spencer's day, of course, an adequate computation of food-components was out of the question. Nevertheless Catalysis was known to him, and with his usual acumen and circumspection he points out that “there is great reason for thinking that to this kind of action is due a large amount of vital metamorphosis.”

Leaving it to the future to decide how large a share of vital metamorphosis (of symbiogenesis!) is due to catalytic action, and what kind of dynamics are here involved, Spencer confines himself to the physical and chemical behaviour of the four chief elements (Oxygen, Hydrogen, Carbon, Nitrogen) which "in various combinations make up living bodies."

He notes the extreme chemical indifference shown by nitrogen, and likewise the low stability and small activity of the animal bases (albuminoids), such as urea, kreatine, kreatinine, as compared with the stabilities and activities of the simpler inorganic compounds.

It is, in particular, the nitrogenous constituents of living tissues—albumen, fibrin, and casein, and their allies—in which that molecular mobility, exhibited by three of their components in so high a degree, is reduced to a minimum.

The chemical characteristics of these substances are instability and inertness carried to the extreme. How rapidly albumenoid matters decompose under ordinary conditions, is daily seen: the difficulty of every housewife being to prevent them from decomposing. It is true that when desiccated and kept from contact with air, they may be preserved unchanged for a long period; but the fact that they can only be thus preserved proves their great instability. It is true, also, that these most complex nitrogenous principles are not absolutely inert: since they enter into combinations with some bases; but their unions are very feeble.

We shall have to recur to the bio-dynamic significance of the "nitrogenous principles." Meanwhile, we will bear in mind their important characteristics as apparent already in Spencer's day. Spencer also provides some useful hints towards an interpretation along general mechanical lines of the *rôle* played by the physical peculiarities of the elements in organic compounds. This is what, he says, an enquiry promises to bring out:—

Proceeding on mechanical principles, it may be argued that the molecular mobility of a substance must depend partly on the inertia of its molecules; partly on the intensity of their mutual polarities; partly on their mutual pressure, as determined by their aggregation, and (where the molecules are compound) partly on the molecular mobilities of their

component molecules. Whence it is to be inferred than any three of these remaining constant, the molecular mobility will vary as the fourth. Other things equal, therefore, the molecular mobility of atoms must decrease as their masses increase; and so there must result that general progression we have traced, from the high molecular mobility of the uncombined organic elements, to the low molecular mobility of those large-atomed substances into which they are ultimately compounded.

Applying to atoms the mechanical law which holds of masses, that since inertia and gravity increase as the cubes of the dimensions while cohesion increases as their squares, the self-sustaining power of a body becomes relatively smaller as its bulk becomes greater; it might be argued that these large, aggregate atoms which constitute organic substance, are mechanically weak—are less able than simpler atoms to bear, without alteration, the forces falling on them. The very massiveness which renders them less mobile, enables the physical forces acting on them more readily to change the relative positions of their component atoms; and so to produce what we know as re-arrangements and decompositions.

It is clear that these conclusions (avowedly very tentative) are yet but partial biological interpretations, although, as the study of surface-tension has startlingly revealed, they contain important elements of truth. First of all, terms like “polarity,” and particularly “mutual” polarities, take too much for granted. The user of these terms may pretend to be supplying a purely mechanistic interpretation of biological facts, but in reality by tacit implication he is raising the mechanism to the body. It remains to be seen in each case how much of character, of personality, and of work such terms take for granted. In my view every “polarity,” like every integration depends primarily on work, and polarity is nothing but bio-dynamic character. Failing this recognition, “polarity” has to this day remained a mysterious concept—a mere word, convenient as a cloak of ignorance or a symbol for the unknown which makes the equation possible to state. It only generalises the problem instead of solving it, as we can see from the following definitions:—

Sir E. Ray Lankester states (*Daily Telegraph*, 16/6/13) that “the real determining ultimate cause of form is in each case, in each living thing, the immense and special heritage

within its substance of polarities and correlations derived from millions of ancestors each of whom has contributed a fraction."

But the mere derivation from ancestors of anything whatever cannot very well be considered an ultimate cause (even so, however, Sir Edwin is constrained to associate the term with "contributions," *i.e.*, "work" of individuals, and we can at least understand how the systematic effort ["work"] of long generations to establish valuable correlations has tended *pari passu* to form the character, as expressed in polarity, of a species). It can, in fact, only be subsequent to the acquisition of something, presently fixed enough to be transmitted for good or for evil; and the view here taken that the production of form, like the establishment of capital and of correlations, ultimately depended on work, seems more rational, more explicit, and more adequate as an explanation of ancestral dynamics and their value than the mere word "polarity" as used by Sir E. Ray Lankester.

Vöchting speaks of "polarity" as a fixed inherited character, a definition which, though more a statement than an explanation of the facts, at any rate would seem to emphasise "character."

Klebs finds this definition of Vöchting's insufficient, "as nothing can be deduced from our present knowledge as to the *causes which led up to polarity.*" (*Italics mine.*) He thinks one great cause of polarity must be seen in the flow of food-substances. The flow of substances, however, we have seen to be ultimately determined by symbiotic (bio-economic) factors.

Goebel's conclusion (*Einleitung in die experimentelle Morphologie der Pflanzen*, Chap. V.) also seem to point to the mutual adaptation for work and for reciprocal food-supply on the part of the plantagens as the chief determining factors of polarity in plants.

He is of opinion (p. 223) that "die lebenden Zellen nicht nur als Leitungsbahnen für Baumaterialien, sondern auch für die Leitung von Reizen, die von einem Organ auf ein

anderes ausgeübt werden können, in Betracht kommen" (the living cells not only minister to the flow of nutrition, but also transmit other stimulations as between organs and organs).

External forces such as gravity are, as he says (p. 220), "für die Polarität von untergeordneter Bedeutung" (of little importance in polarity). Again, we see that the only remaining factors that can thus be seen as of importance are the bio-economic (symbiotic) factors.

Goebel shows (p. 230) that if any part of a plant receives a "lebhaftere Stoffwanderung" (i.e., as I would say, if any part is the recipient of a prominent share of nutrition by way of remuneration in virtue of the prominence and importance of its function), the polarity of that part is "schärfer ausgeprägt," i.e., is more marked and more thoroughly established.

A polarity thus well established (like a good steady character) is not so easily interfered with as one that is less significant. A disturbing factor always consists in a "Verarmung an Baumaterial" (p. 234)—an impoverishment of building material.

Amongst the lower forms of plants, e.g., *Marchantia* and Liverworts, Goebel notes the strange fact that "andere Thallusteile anders 'polarisiert' erscheinen als der vegetative, unbegrenzt weiter wachsende Thallus," i.e., that exaggerated vegetative growth is connected with quite a different polarity from that in more normal growth. We have seen that such exaggerations are attended by a diminution in the output of work, and are generally caused by a surfeiting nutrition, and again we must conclude that our bio-economic explanation is calculated to throw light on "das noch recht dunkle Gebiet der Polarität" (the yet very dark region of polarity).

To return now to Spencer: It is true that "the molecular mobility of atoms must decrease as their masses increase"; but whether a large-atomed compound is sufficiently mobile and efficient in its work—the point that really matters—depends less on mechanical than on "personal" factors.

The self-sustaining power of an organism suffers from increasing bulk only in so far as the increase is abnormal, *i.e.*, at the expense of character, of proportion, and of symbiotics. Every normal increase of size is secured against "mechanical weakness" by new correspondences symbiotically gained. It is only where there is a loss of symbiotics and a resultant loss of correlated support that "mechanical weakness" (and general pathology) must ensue. It is precisely such symbiotically unprotected parts of "massive" organisations which provide a favourable soil for alien forces "falling on them," with the result of decompositions. *Ubi uber, ibi tuber*. The extinction of many monstrous forms of higher life, *e.g.*, certain ruminants) is now believed to be due to the ravages of parasites quite as much as to mechanical weakness, and this means in reality that their resistance had become lower, and that as a consequence of their depredation on plants they had to be content with inferior fare, and with diminished and inferior correspondences, and thus in the end provided the soil for microbic infection. The biological cause of weakness is thus coming more and more to be acknowledged as of greater importance than, and indeed as determining, the mechanical weakness.

That certain modes of feeding are primarily responsible for stimulation towards great size and monstrosity, I have already pointed out. In cases of surfeit, as we have seen, vegetative growth proceeds abnormally at the expense of sexual development, and cell-division may become retarded. As Prof. M. Hartog has it, a cell may from its own gluttony become too obese for even this activity (of cell-division), and so it does not divide, even though Spencer's limit be seemingly long past.

If great bulk and impressive massiveness are, mechanically speaking, conducive to weakness, there is all the more reason for bio-economic restraint on the part of the organism. All the more reason for "noblesse oblige" and for an avoidance of anti-biotic conduct and of food constituents that

tend towards sluggishness. If in a particular kind of food the extremely inert element Nitrogen is present in undue proportions which, no doubt, is the case wherever proteins are too exclusively consumed, this must induce sluggishness and obesity (accumulation of waste matters), giving the appearance of exuberance of growth in many organs and tissues. This exuberance may in the course of several generations lead, though pathogenetically (as we shall see more fully anon), to a huge increase of size—a giant race morbidly bred. A race of in-feeders, though really on the path of degeneracy, may thus outstrip its former cross-feeding allies so far as individual size is concerned. The experiment, however, seeing that it results in the loss of symbiotic correspondences and general morbidity, cannot lead to permanent good results, but must on the contrary conduce to increasing liability to “decompositions” of all kinds, physiological and social.

Prof. Houssay (Sorbonne) has shown by experiment that to feed fowls on a meat diet, *i.e.*, mainly protein, is to cause extinction of the race in a few generations, although generally and for a time it is quite possible to obtain greater bulk by a change from a mixed diet to a more purely in-feeding, *i.e.*, proteid diet.

That, failing sufficient molecular mobility, there is great liability to accumulation of waste matter had not escaped Spencer. This is how he deals with the contingency:—

And now we may clearly see the necessity for that peculiar composition which we find in organic matter. On the one hand, were it not for the extreme molecular mobility possessed by three of its chief elements out of the four; and were it not for the consequently high molecular mobility of their simpler compounds; there could not be this quick escape of the waste products of organic action; and there could not be that continuously active change of matter which vitality implies. On the other hand, were it not for the union of these extremely mobile elements into immensely complex compounds, having relatively vast atoms that are made comparatively immobile by their inertia, there could not result that mechanical fixity which prevents the components of living tissue from diffusing away along with the effete matters produced by the decomposition of tissue.

We may infer that, so far as mechanics alone are concerned, every compound depends on the balance of opposite and mutually complemental factors, such as relative activity and relative passivity. Failing a due balance, serious danger must arise to the living tissue by its becoming "infected" with the disintegrating tendencies of waste or foreign matters, *i.e.*, an organic body has to rely also on the physical "good" character of the composing matter. Although from mechanical to physiological balance is a far cry, yet we must concede that in general every organic compound depends in some such way on balance of complementary factors. That this holds good of the higher factors which are superposed on the mechanical factors we have already seen. How much of each factor is required for a due bio-dynamic balance remains to be seen in each case, and depends finally on bio-economic conditions. Though, of course, the relatively inert constituents of organic matter help to prevent the components of living tissue from diffusing away along with the effete matters, yet the case of the *Convoluta* provided us with an illustration of the way in which biological requirements and the forces at their disposal materially alter the distribution of forces in the organism which would result from merely chemical and dynamical reactions; for in that organism we saw the excretion of waste matters was replaced by their complete retention and conversion to new symbiotic uses, though this was in the particular case of a retrograde symbiosis.

Evolution in general is more than a mere mechanical "redistribution of Matter and Motion"; it is a symbiogenetic process the ultimate result of which is determined by values in my special (social) sense.

The presence of super-mechanical factors as well as the concurrent primordial and eternal need of compromise and of balance between complemental opposites, may also be gleaned from other considerations of Spencer in the cases of colloidity and crystallinity, diffusibility and indiffusibility, fluidity and solidity.

In discussing the two forms of aggregation already alluded to under which all solid substances exist, the colloid and the crystalloid, Spencer endorses the following conclusion of Prof. Graham:—

The colloid is, in fact, a dynamical state of matter, the crystalloidal being the statical condition. The colloid possesses *energia*. It may be looked upon as the primary source of the force appearing in the phenomena of vitality. To the gradual manner in which colloidal changes take place (for they always demand time as an element) may the characteristic protraction of chemico-organic changes also be referred.

We have already forestalled these conclusions as regards the colloids and endeavoured to amplify them in the light of modern research.

Evidently with the colloids we reach a distinctly higher stage than usually associated with the crystalloid. We are here dealing (in Prof. Graham's words) with incipient "vitality," with a "characteristic" mutability (suggesting an incipient personality). The difference of "livingness" is but one of degree, but it is of vital account so far as the bio-dynamic and therapeutic use of either colloids or crystalloids is concerned.

In his *First Principles*, Spencer prefers the term "force" to "energy," and thinks the term "persistence" (of force) preferable to "conservation" (of force), on the ground that the word "conservation" implies a conserver and an act of conserving, while in the "*Biology*" we are allowed the term "*energia*" without an attempt even to remove the implication of personality. What is it that energises the matter?

If, however, a sort of personality is in any way involved on the analogy of human personality, then we can understand that time is required for this personality to realise its powers and to do its work and to build up its psychological and physiological capital.

We have in these colloids, says Spencer, "just the required compromise" (*i.e.*, a symbiogenetic balance of opposites) "between fluidity and solidity. They cannot be reduced to the unduly mobile conditions of liquid and gas;

and yet they do not assume the unduly fixed condition usually characterising solids. The absence of power to unite together in polar arrangement leaves these atoms with a certain freedom of relative movement which makes them sensitive to small forces, and produces plasticity in the aggregates composed of them."

They are specially fitted, as he further points out, for *plastic* purposes, which would indeed remind us that a peculiar importance must attach itself to the fact that the force of surface-tension is of particular dominance in the plastic world of the colloids. Surface-tension makes for economy of form and is an important basic factor in the "objective" elements of beauty and of utility. So much so, that we may say that normally, when by itself, in the plastic state, every aggregate, every cell, every organism, is tending not only to perform work, but also to become a work of art in itself, which is also saying, in other words, that it is endeavouring to be free from impeding impurities, *i.e.*, healthy (surface-tension, as a matter of fact, has the effect of drawing out all over the surface any impurities that may settle on it).

The importance of the *plastic* unicellular stage, allowing, *inter alia*, of the entanglement and separation of suspended impurities, through which every organism in its ontogenetic development has to be passed for purposes of rejuvenescence, of health, and of work, may thus again be seen as greatly enhanced. The evolution of colloidity itself, as already surmised, may thus perhaps be viewed as a symbiogenetic compromise achieved by life in the solution of the combined problems of pure physical existence—Spencer's required compromise between fluidity and solidity—and of the constant preservation of a healthy, *i.e.*, duly balanced, economic and physiological basis of evolving life, consisting of a great complexity of life-purposes, requiring adequate relations in its various inorganic and organic ramifications. The requirements of at least three mechanisms, as it were, have to be satisfied in this symbiogenetic compromise:

the physical, the chemical, and the biological; hence arises a great complexity of inter-connected factors, and hence also the difficulty of assigning its due value to each one of them. That the biological factor, in the widest sense of the word, easily becomes the most important of all, we have already seen, and it becomes again apparent from the following passage of Spencer with which he concludes his chapter on "organic matter":—

To all of which add, that the state of warmth, or increased molecular vibration, in which all the higher organisms are kept, increases these various facilities for re-distribution, not only as aiding chemical changes, but as accelerating the diffusion of crystalloid substances.

Obviously the biological factor is here sprung upon us too suddenly, for Spencer provides no previous introduction. Again we must ask what it is that keeps organisms warm and in sufficient molecular vibration? And again the answer is that it is "work" in one shape or other, failing which organisation must cease to progress and ultimately decay.

No amount of disposition on the part of organisms to live by short cuts, that is to avoid systematic work by getting foreign supplies of warm blood in dishonest ways, can blind us to the fundamental fact that physiological capital is primarily and constantly produced by work, and that the normal rule of life is for all organisms thus to provide their own warmth, circulation and evolution. The majority of organic workers, though ever so inconspicuous—*vide* the humble plant, the humble bee, the humble earthworm—have elected to lead a strenuous work-a-day life and to produce their own "warmth" and their own sustenance and even surpluses to spare for others. That a plant's usual temperature is slightly raised in the seed, in its "love-food" laboratory, we have already noted. Thus early we see is the need of the production of warmth by industry, both domestic and biological. Darwin rightly pointed out that to be highly (progressively) active, the brain must be bathed with warm blood, and that this is best achieved by aerial respiration. He also notes that the

terrestrial organisms, because of the more complex relations to their environment, enjoy a quicker rate of change than the aquatic, which is saying, in other words, that mutual industry is more complex on land than in the water; and that, hence, the higher evolution of terrestrial beings is a matter of increased bio-economic specialisation, involving as it does increasing bio-chemical perfection. That the "cold-blooded" and predaceous crocodile is a failure from this point of view, we have already seen.* Whilst biological factors are thus more important than Spencer's treatment would make us believe, we are also led now to concede a more incipient "biology," i.e., character, response and even perhaps incipient "consciousness" to organic and, to a lesser degree, even to inorganic matter.

The possibilities of response to stimulation by inorganic matter and the phenomena of the fatigue, "illness," and dissociation of metals which have recently come to light, are further confirmation of the view here taken that the constitution even of ordinary inorganic components is more complex even in "personal" components than has hitherto been believed. I have given expression to the same thought in my *Nutrition and Evolution* by stating that inorganic matter bears, as it were, upon its shoulders the superstructures of organic life—as Atlas the vault of heaven. In the same volume I have tried to show that the phenomena of the dissociation (illness and decay) of matter bear throughout a parallelism to those of organic "dissociation" (pathogenesis). In the July number of the *Nineteenth Century* (1914), Dr. Arabella Kenealy propounds a similar thesis ("Is man an electrical organism?").

Thus speaking of the (symbiogenetic?) importance of water, she says:—

*The *Cetacea* and their equivalents in degeneracy and monstrosity from the secondary period of geological time—viz., the monstrous marine reptiles, are descended from quadrupeds which formerly lived on the land and, therefore, were physiologically superior to their descendants. The latter, though at one time widely distributed, "suddenly" became extinct, which is considered a mystery. Prof. S. W. Williston suggests that the races may have become effete and died of old age. My explanation is, as in the case of the megatherium, that these races have arrived at a blind alley of evolution because of their persistent transgression against the law of symbiogenesis. *Hinc subitae mortes atque intestata senectus.*

A man lives and thinks and feels and acts, by power, absolutely of retaining within his complex cells—a measure of water. Both flower and man can live longer without food than they can live without water.

What then is Water—this mystical, ductile, limpid, lovely, iridescent, smiling thing? This treacherous, forceful, resistless, terrible, tremendous thing; without which, alike in its meekness and in its potency, earth would be a spectral Sahara, colourless, lifeless, mindless, loveless?

It seems forced upon us to believe that Water may be highly-tempered Electricity, liquid and latent, and yet not so far transformed from its more strenuous mode as to be unrecognisable.

Oxygen, “the life-giving air,” very breath of life as it is, would seem to be, indeed, molecular electricity, generated by vegetation from the waves of electrons which the sun rains down upon us in unceasing flow.

In the air it exists as a molecule, a positive atom yoked, it may be, to a negative atom, and subjugated further by insulation of the inert nitrogen.

In water, oxygen is still further subjugated by its yoke-mate hydrogen. It becomes thus snow for the lily-cup; milk for the babe. Yet at a call it rises in force irresistible; rushes in river, forges in torrent, towers in iceberg, or, as steam, reveals its Titan power in the thunder of turbines.

The same writer states:—

There is evidence that the negative corpuscle, a number of which corpuscles keep the positive electron at poise in the atom, although a thousand times smaller in size, is nevertheless equal in potency to the positive electron. This would seem to imply that the blind destructive force is antagonised a thousandfold by its counterpoising mate.

And further:—

Radium, the forces in the atom of which are no longer held in equipoise and conservation, but are perpetually discharging themselves from intra-atomic stability and thus travelling toward self-annihilation, shows us the blind destructive mode of *prima materies* when no longer held static, and so rendered constructive and evolutionary. The Radium atom—the most active atom known, which is all the while degenerating into Lead, the most inert—must be regarded accordingly as Matter in course of devolution.

The Radium atom would seem to be thus a miniature hell in which, having become de-polarised from Higher Ordinance, it consumes itself in its own fires. And despite some scientific enthusiasms concerning it, because of certain alternative effects exerted by its emanations upon living tissues (suppressions of symptoms is not cure, however), its

influence would seem to be malign—witness its powers of rendering sterile those who work with it, showing it to traverse the great law of Creative Life.

We thus see again how everything in nature depends on character and on a proper balance of opposites, on behaviour of characters that may almost be called purposive in so far as its subservience to cosmic or symbiogenetic ends is concerned.

“Grant but sensibility,” says Spencer in his *First Principles*, “with no established power of thought, and a force producing some nervous changes, will still be presentable at the supposed seat of sensation.” Spencer has thus to take for granted something that is interpretable in terms of personality, by which assumption and its associated hiatus only he can pass to the consideration of those “sensitive” and “plastic” aggregates which carry us to the higher organisms, which manifest sensibility in its most striking forms. But there is a long interval there, and no mention is made of nutrition as an important function of these higher organisms, and that even the colloids must grow by analogous processes though here but termed “accretion,” that is to say that for the development of these higher functions a manipulation of raw materials, a manufacturing process or “work” is required. In short, we are brought back to bio-economic values and the creation of physiological capital even at this elementary stage of evolution, and this getting of food cannot be dissociated from consciousness, however incipient, as Samuel Butler has urged long ago.

B.—THE ACTIONS OF FORCES ON ORGANIC MATTER.

In this chapter Herbert Spencer discusses the sensitiveness displayed by organic matter to certain forces that are *quasi-mechanical*, if not mechanical in the usual sense.

One peculiarity coming under this head is the “power” of colloids (called “capillary affinity”) to take up a large quantity of water: undergoing at the same time great increase of bulk with change of form. The other—already related—

peculiarity of this kind is "Osmosis," the widespread but "not yet fully understood" phenomena showing a double transfer of solutions of different densities when on opposite sides of a permeable (especially colloidal) system. "Very many of the conspicuous changes of form undergone by organic germs, are due mainly to the permeation of their limiting membranes by the surrounding liquids."

What is omitted, however, is that, as we have seen, protoplasm makes its own adaptations, its own osmotic arrangements, and selects its own food; on which selection indeed the subsequent osmotic arrangements are largely dependent. The living substance of the plant, for instance, secretes over its surface a skin of cellulose, or some analogous substance, whilst, broadly speaking, that of the animal does not, and this difference, as Prof. Bretland Farmer says: "from the start was fraught with consequences of the greatest importance, and has profoundly affected the entire course of development in the two Kingdoms respectively."

This difference we have to regard, I believe, as an early protoplasmic adaptation in accordance with bio-economic requirements, *i.e.*, with those of biological symbiosis. It was in the course of symbiogenetic evolution that the plant formed its important character for work which has remained for all these ages the outstanding feature of plant-life. That the plant at the same time remained sensitive to many mechanical and quasi-mechanical forces, that it had to adapt itself to varying conditions of osmosis is, of course, true, but evidently all mechanical adaptations are subordinate to a fundamental bio-economic adaptation.

Exceptions are supplied by cases coming under the head of "extreme determination," *i.e.*, biological abnormalities due, as already explained, to a swerving from the path of bio-economic usefulness. These exceptions, however, may be said to confirm the rule. It is only in pathological cases that an organism—precisely because of loss of character—becomes "extremely determined" by mechanical factors. It is indeed

to such a degenerate organism that the term "quasi-mechanical" should be applied. Such is the frailty of organic life that under temptations it is apt to sink to a quasi-mechanical level where a biologically negative (merely mechanical) resultant tends to obtain predominance at the expense of a purposive (symbiotic) resultant and pathological conditions consequently become dominant.

Spencer concedes in a general way that it is the fundamental difference of character between plant and animal which produces the great chemical contrasts between those complements in the great synthesis of life.

We have next to note, as having here a meaning for us, the chemical contrasts between those organisms which carry on their functions by the help of external forces, and those which carry on their functions by forces evolved from within. If we compare animals and plants, we see that whereas plants, characterised as a class by containing but little nitrogen, are dependent on the solar rays for their vital activities; animals, the vital activities of which are not thus dependent, mainly consist of nitrogenous substances. There is one marked exception to this broad distinction, however; and this exception is specially instructive. Among plants, there is a considerable group—the *Fungi*—many members of which, if not all, can live and grow in the dark; and it is their peculiarity that they are very much more nitrogenous than other plants. Yet a third class of facts, of like significance, is disclosed when we compare different portions of the same organisms. The seed contains nitrogenous substance in a far higher ratio than the rest of the plant; and the seed differs from the rest of the plant in its ability to initiate, in the absence of light, extensive vital changes, the changes constituting germination. Similarly in the bodies of animals, those parts which carry on active functions are nitrogenous; while parts that are non-nitrogenous—as the deposits of fat—carry on no active functions. And we even find that the appearance of non-nitrogenous matter, throughout tissues normally composed almost wholly of nitrogenous matter, is accompanied by loss of activity: what is called fatty degeneration being the concomitant of failing vitality.

It is thus clear again that, in spite of all temptations to the contrary, plant and animal have in the main and for æons of time steadily kept on their respective paths, have throughout obeyed a definite biological law, viz., that of symbiogenesis, have avoided short cuts and in particular the dangers

of "nitrogenous" or of "fatty" degeneration, *i.e.*, those of malnutrition by in-feeding, which by reducing organisms to the "quasi-mechanical" level of existence and distorting the ratio of their erstwhile chemical and bio-chemical differences of composition *mutatis mutandis* also ends in obliterating their vitally important bio-economic specialisation for "work," their character and status.

The exceptions from the norm of life are indeed instructive. We have seen that the *Fungi* belong to a group which have, to a great extent, retrogressively changed their character from one associated with an erstwhile strenuous career to one associated with relative indolence, and that *pari passu* their composition has changed from a physiological to a relatively pathological condition, and their position in nature from one of strenuous independence to one of precarious dependence. It is, no doubt, within the power of all plants to indulge (retrogressively) in surfeit of nitrogenous or other fare. But the majority of plants have evidently elected not to swerve from the symbiogenetic path, but to maintain a good (symbiogenetic) behaviour. They have not aped certain animals in becoming excessively nitrogenous, but as eternal givers have specialised instead to provide ideally balanced food-substances for the animal, thus aiding its digestive and genetic transformation, *i.e.*, its evolution.

Their good (constant and symbiotic) behaviour has thus assured the survival and progress of the organic world, whilst rendering the "nitrogenous" animal dependent, and contributory to a far higher degree than Spencer's passage would lead one to suppose. Indeed, we may say in a general way that the more nitrogenous fare an organism requires, the more biologically dependent it becomes. Frugality is here, as in human relations, the prime requisite of genuine independence and reliable character.

The magnificent and terrible hamadryad, a snake which as the *Times* says (20/7/14) would be the most awful scourge of all living things, is yet permitted by nature "to live only

on terms which make it comparatively innocuous; for the diet of the hamadryad, or King cobra, consists almost entirely of other snakes," *i.e.*, the life and range of such a fastidious creature are strictly limited and dependent. A creature of this kind is so hopelessly divorced from its true complement in nature, that not uncommonly it must starve in the midst of plenty, which precarious condition itself is equivalent to a pathological condition. Yet, as the Italians say, "*Non fu mai vista capra morta di fame.*"

According to Prof. J. B. Farmer it is strictly in relation to two overwhelmingly important functions, provision of water and of photosynthesis, that vegetation has assumed its form. The complexity of structure, he says, is intimately related with a corresponding differentiation and specialisation of function. The fungi and many parasites, according to this botanist, have "solved" the great vegetable problem of existence "in another way altogether." Assuredly, however, the majority of them have not solved it in a satisfactory manner, not at any rate in accordance with the "overwhelmingly" important symbiogenetic principle which, I hold, pre-eminently characterises normal plant adaptation.

If, therefore, the exceptional case of the fungi and other similar organisms that have "slipped out from the main streams of evolution into the quiet backwaters of life" is specially instructive, it is because it shows that genuine evolutionary success depends mainly on the production of constant, good and reliable character (with its pre-requisites of symbiotic feeding), which is indispensable to and one of the greatest assets of the world of life. The essential peculiarity of the majority of fungi is not merely that they are very much more nitrogenous than other plants, particularly as their nitrogen contents represent but borrowed capital, but that they have sacrificed a career of strenuous independence for one of idle dependence, and consequently have lost character and status and have become inferior to other plants with regard to the production of bio-economic values in which they are

notoriously very deficient. "By their works shall ye know them."

Again, the fact noted by Spencer that the seed of a plant contains nitrogenous substance in a far higher ratio than the rest of the plant belongs to a different order of facts from that of the nitrogenous composition of the *Fungi*. If, as Prof. J. B. Farmer says, vegetation has assumed much of its present form in relation to "overwhelmingly important functions," this is true in particular of symbiogenetic functions, and such broad consideration is calculated to throw light on the significance of nitrogen accumulation in seeds quite as much as on that of reproduction generally. The example of the plant shows that it is reproduction and the associated or subsequent demand of special physical expenditure (need of active respiration and of supplying the energy and heat required by the slender stalk to bore through the soil, or maybe the hard snow crust) together with the vicarious purpose, *i.e.*, adequate symbiogenetic maturation of "love-foods," which requires a temporary extra accumulation of nitrogen in the parts concerned, in order, we may thus say, to facilitate a special and vital symbiotic effort. We may reasonably assume that the normal nitrogen requirement of a plant is in keeping with its work, *i.e.*, its symbiogenetic function, and that it is only the abnormally exaggerated and morbid sex-hunger of a saprophyte or parasite which makes for undue requirements of nitrogenous food—in order to finance, as it were, with borrowed capital the ever-increasing deficit of such degenerate species in the household of Nature—borrowings of the kind which sooner or later will bring on overwhelming sorrowings.

We may further conclude, and this is in harmony with observed facts, that as regards animals a more liberal nitrogenous fare is indicated where special and concentrated physical efforts are required, and that where this is not the case, every unused surplus of nitrogenous food must become the cause of morbidity, and give rise to digestive transformations of an undesirable kind. The "fatty degeneration" noted by

Spencer as a concomitant of failing vitality, is very generally due to malnutrition, *i.e.*, to over-feeding and to the gluttony of an abnormal nitrogen hunger, which follows so easily in the wake of indolent (non-symbiotic) feeding and in-feeding. Promiscuous modes of feeding, such as in-feeding, cannot supply a well-proportioned nutrition, but must lead to deficiency diseases and to a morbid craving for surfeit—for sheer lack of those vital principles (vitamines) which proper symbiotic food (“love-food”) so ideally provides.

Seeds are the one great source of all albumen, and knowledge of the sacrificial character of the seed provides a cue as to the use of albumen by both animal and plant. This use must be strictly limited to symbiogenetic requirements, and we have here one form of restraint required to be observed by all strenuous organisms quite as much as sexual restraint and that general restraint which is commonly required by mutual forbearance in life. The evidence provided in the next chapter will demonstrate more fully the profound biological significance of Nature’s abhorrence of a promiscuous and antibiotic use of nitrogenous (albuminous) matter, so generally supplied by perpetual in-feeding.

In summarising his evidence as to the part played by nitrogenous matter in organic changes, Spencer lays emphasis on the facts that nitrogenous compounds in general are extremely prone to decompose: their decomposition often involving a great and sudden evolution of force, and, further, that substances classed as ferments are all nitrogenous.

We must add that the extreme proneness to decomposition characteristic of nitrogenous compounds is frequently fraught with great “infective” danger. The excessive or too exclusive ingestion of nitrogenous matter thus, by direct or indirect chemical action (induction), communicates excessive tendencies towards decomposition. It thus also facilitates the growth of a pathogenic intestinal fauna. This has been shown by Prof. E. Metchnikoff and others. At the Seventeenth International Congress of Medicine (1913), papers were read by Prof. A.

Combe and Dr. Ed. Ceresole, who regard meat foods as exerting a putrefactive effect, whereas milk and carbohydrate foods exert an opposite effect in the intestines. (*Lancet*, 13/9/13.) We are thus gradually coming to draw a vital distinction between the various nitrogenous foods according to their origin, and according to their biological adequacy. Thus Dr. William Brady (*Popular Science Siftings* for May 30th, 1914) urges the beneficence of temporary or prolonged meat fasts. Asked how he knew when a patient is consuming too much meat, he answered: "I make a test. I find the toxic waste products of animal protein—left behind after the digestive ferments in the alimentary canal have given up the job and have been superseded by that indefatigable ally and satellite of senility, the *colon bacillus*."

He further says: "Vegetable protein, or the 'meat' of beans, peas, rice, wheat, nuts, and cereals generally, digests as easily as animal protein, and resists *colon bacillus* changes much better than animal protein."

It is not difficult to see, moreover, that a great sudden evolution of force "due to the decomposition of nitrogenous matter in an organic body" is scarcely conducive to permanent and desirable (progressive) evolution. That such a production of force by the use of nitrogenous (flesh) food in the case of man is generally followed by a lengthened period of great depression, has been experimentally verified by Dr. A. Haig.

Nature in general does not countenance sudden developments. Only hasty climbers and parasites make excessive "explosive" use of nitrogen, and these come to an untimely end. The strenuous (non-accelerating) species rely upon balance and slow, but permanent, evolution of force, which alone is compatible with the discharge of work, with systematic and protracted activity. We have seen in the case of the lichen what a startling difference from every point of view it makes if a fungus re-enters the strenuous union of biological symbiosis. Its composition changes with its usefulness, and it matches many of the higher organisms in longevity.

The "ferments" themselves (to which Spencer alludes) are the products of a very slow and reciprocal co-operative evolution, to which, indeed, they owe their adequacy. Their efficacy and range of power changes *pari passu* with other important changes in the organism. Hence to argue from their composition as to the requirements of nitrogen by organisms is at best *post hoc* but not *propter hoc* argument. In many instances we find the ferment possessed by pathogenic organisms confined in their efficacy to their peculiar "food," i.e., it can act only on the bodies (or very similar material) of those morbid organisms (hosts) on which they batten, but they cannot produce the same decomposing effects upon other material or upon the tissues of healthy organisms. We may say that the ferments in these instances have become reduced and limited in symbiogenetic efficacy *pari passu* with the general loss of life-energy and of symbiogenetic status (correspondences) on the part of the degenerate organism.

Further, in a paper read before the Seventeenth International Congress of Medicine (*Lancet*, 6/8/13), Prof. O. Folin (Harvard) pointed out that urea, the chief nitrogenous waste product, is not an oxidation product of the nitrogenous materials. "The animal body," he says, "is not capable of oxidising the amino groups contained in nitrogenous materials taken as food (which food?), and the urea formation, as I look at it, is perhaps the most important mechanism for preserving the neutrality of the body fluids. If it were not for the urea formation, the body fluids would become loaded with ammonia. The urea represents, therefore, chiefly a metabolism of *superfluous nitrogen in the food*." (Italics mine.)

Thus we see how great are the difficulties of the animal body to deal with a surfeit or with what is more than strictly required—of nitrogenous food. Moreover, there is a qualitative difference; for some of the amino groups our body cannot oxidise at all, and must store them away as waste matter and try to eliminate them as best it can, though frequently with pathological concomitants.

Dr. H. W. Bywaters states in *Science Progress* (Oct., 1914) that if the protein element is deficient in certain amino-acids, *especially in aromatic* amino-acids, such as tyrosine and tryptophane (with which the vitamins are closely associated), no superabundance of the other amino-acid constituents will compensate for the deficiency, and the food is unable to maintain the integrity of the living tissues. Truly, as he says, "the essential factors of a complete diet are more numerous than was formerly suspected."

He also tells us that the peculiarity of structure of vitamins and hormones suggests that their *elaboration is dependent upon the presence in the food* of materials (special "love-food" material!) essentially different from the common (which ?) proteins, carbohydrates and fats, and that for the detection of anti-beri-beri vitamins, for instance, we must look chiefly to milk, oats, wheat, barley, maize, beans, cabbage and other vegetables ("love-foods"). Both Prof. Folin's and Dr. Bywaters' observations again confirm what I have said as regards the need of discrimination of foods for purposes of health and of progressive evolution. It further shows that what I have stated concerning the ferments, viz., that they owe their evolution, composition and efficacy primarily to symbiogenetic evolution, is also true of hormones and vitamins (which latter, as we have seen, Dr. C. Funk regards as the mother substance of ferments).

The primitive notion about "impure blood," says Prof. Folin, "has a kernel of truth in it," and he states, further, that in middle-aged adults perfectly normal kidneys are the exception rather than the rule.* In other words, the whole system generally becomes over-charged with poisonous products of nitrogen metabolism, which the eliminative forces eventually fail to cope with. By a careful selection of a low nitrogen diet, however, it was possible to reduce the amount of work required of the kidneys to a level at which they were

* It is only too true that, as Emerson says, "We are breeding men with too much guano in their composition."

able to keep the waste products in the blood within normal limits.

The following figures were obtained in four days by means of a diet consisting chiefly of carbohydrates. ("It would seem," says Dr. Bywaters, "that the vitamine is particularly concerned with the assimilation of the carbohydrate element of the food.")

Blood Nitrogen (in the case of Nephritics).

On the regular hospital diet.	After the low nitrogen diet.
32 mg.	19 mg.
40 „	19 „
62 „	30 „
44 „	19 „
58 „	23 „
37 „	20 „
82 „	26 „
30 „	20 „
37 „	23 „
48 „	22 „

That a return to greater sobriety in matters of nitrogen ingestion is indicated not only to achieve a return of conditions of health, but also in order to maintain health at its highest at all times and for the highest purposes, becomes clear from a consideration of Sir Ernest Shackleton's diet during his exploration of the Arctic regions:—

Breakfast consisting of 2oz. of lard per man, 2oz. of sugar, 1oz. of dried milk, wheat protein and oats.

Lunch consisting of foods composed of brazils, almonds and beech nuts mixed with oil, and dried milk and oats.

Dinner consisting of the same food in the same quantity as at breakfast.

We cannot but be struck by the predominance of "love-foods" in this dietary. Moreover, each man was only allowed 35oz. of food a day, as compared with the 48oz. which the average Londoner consumes. It speaks volumes for the

efficacy and adequacy of "love-foods" thus to see that a relatively smaller amount than "usual fare" has carried these men whole and hearty through the greatest feats of endurance and of hardship. Indeed, wherever we look for evidence the same facts are fast becoming apparent.

Recent research has also shown that very generally it is a deposit of nitrogenous matter in the muscles (Kinotoxin) that is the cause of fatigue, and that the ingestion of certain quantities of nitrogenous food is detrimental to the capacity for work. We can now see that to study the special sensitiveness of organic matter without taking into account the concomitant bio-economic implications must be misleading—"habet die Teile in der Hand, fehlt leider nur das geistige Band."

It is, indeed, a curious and significant fact, as Spencer also notes, that nitrogen enters so indispensably into the composition of gunpowder, and, as we can see here, most strikingly with possibilities of conferring death-dealing effects. Here we have but a conspicuous example of the ill-effects wrought by nitrogen when used in certain ways, *i.e.*, when it is suddenly liberated from certain restraining associations, *i.e.*, from useful service.

It is thus with nitrogen and with gunpowder as it is with sex and with fire, concerning which Schiller says:—

Wohlthaetig ist des Feuer's Macht
Wenn sie der Mensch bezaehmt, bewacht,
Doch furchtbar wird die Himmelskraft
Wenn sie der Fessel sich entrafft,
Einher tritt auf der eig'nen Spur
Die freie Tochter der Natur.

C.

In his chapter on

THE RE-ACTIONS OF ORGANIC MATTER ON FORCES,

Spencer tells us:—

Redistributions of Matter imply concomitant redistributions of Motion. That which under one of its aspects we contemplate as an alteration of arrangement among the parts of a body is, under a

correlative aspect, an alteration of arrangement among certain momenta whereby these parts are impelled to their new positions. At the same time that a force, acting differently on the different units of an aggregate, changes their relations to each other; these units, reacting differently on the different parts of the force, work equivalent changes in the relations of these to one another. Inseparably connected as they are, these two orders of phenomena are liable to be confounded together. It is very needful, however, to distinguish between them.

We have seen that nutritional habits are particularly responsible for changes of momenta and of correlations, and that such changes are connected with a parallel set of changes in domestic and biological symbiosis.

Certain mammalia, for instance, having in the past for reasons we need not here go into, made the change from cross-feeding to in-feeding; this in course of time implied new physiological momenta as outwardly expressed in corresponding changes of form and of structure. Thus there arose great canine teeth with vast fangs, with concomitant correlated changes upon the whole anatomy of the animal.

As was pointed out in *Evolution by Co-operation*, the coming of vast teeth and fangs entailed an excessive blood-supply to these parts at the expense of that formerly (normally) going to the brain, and in the long run in-feeding leads to that huge increase of size through geological periods which is so puzzling a phenomenon to modern Biology, seeing that it is generally the reverse of useful even to the particular species. Were it a normal process and congruous with the requirements of progressive evolution generally, such an increase of size should be "useful" and attended by a commensurate development of brain, which manifestly, however, it is not. But the supply of food-force in these instances is not adequate enough for purposes of domestic or of biological symbiosis to produce permanently desirable normal results. The "simultaneous re-distribution undergone by the forces" is such as eventually to produce stimulation of some organs at the expense of others, i.e., an unwholesome asymmetry. Predaceous feeding eventually produces absurdly overgrown bodies with absurdly

small brains. Such one-sided results show that correlation, *per se*, provides little help, and that in the absence of proper and genuine relations of an organism to the world, mere correlation may, indeed, eventually assist in the destruction of the organism. Spencer perceives that there is a correlation between the changes of forces from without and those within, but he overlooked the fact that biological symbiosis and symbiosis generally determine the inner set of changes, as they also determine their legitimacy and their harmony with those without; in short, their bio-dynamic value.

In "La Démocratie devant la Science," C. Bouglé reminds us of the following important anatomic and correlated bio-economic (social and bio-moral) facts:—

Si la lutte développait toutes les qualités, les cerveaux les mieux organisés devraient appartenir aux plus grands lutteurs. Tout au contraire, ils se rencontrent plutôt chez les espèces sociables. Les passereaux sont supérieurs en ce point aux accipitres, et les herbivores aux grands félins. Bien loin que l'association ait entraîné une sorte d'arrêt de développement dans l'organisation cérébrale, il semble qu'en stimulant la vie représentative, en multipliant les unes par les autres les impressions des individus rassemblés, elle ait perfectionné chez eux l'appareil de la coordination.

It is necessary to add that an adequate physiological (symbiotic) basis is indispensable to the maintenance of organic solidarity and to the progress of all co-operative relations between living beings. With this proviso we will agree with Bouglé's further remarks:—

La flamme de la conscience ne descend que sur la tête des êtres dont l'appareil nerveux est suffisamment ramifié et unifié . . . Voilà pour quoi nous glorifions justement les êtres différenciés et les louons de consommer les matériaux préparés par d'autres; car seuls ils les emploient à une œuvre immatérielle, car seuls ils ont construit, comme dit le poète italien, un trône pour le dominateur qui va venir, un poste d'honneur pour l'esprit. . . . En un mot, là où les sociétés animales sont développées, on ne reconnaît pas seulement les dehors matériels, on devine les dessous spirituels d'une civilisation véritable.

Spencer notes an important difference of constitution between inorganic and organic matter:—

At the outset we are met by a difficulty. The parts of an inorganic mass undergoing rearrangement by an incident force are, in most cases, passive—do not complicate those necessary reactions that result from their inertia by other forces which they originate. But in organic matter the rearranged parts do not react in virtue of their inertia only: they are so constituted that the incident force usually sets up in them other actions which are much more important. Indeed, what we may call the indirect reactions thus caused are so great in their amounts compared with the direct reactions that they quite obscure them.

I would interpret this passage to mean that what I have termed symbiotic, *i.e.*, purely biological actions and reactions, are in reality more important than the merely mechanical ones, and as such complex organic substances are formed by, or in obedience to, symbiotic activities, the more complex reactions they set up may be said to be produced by the character and behaviour of the organisms concerned. It is thus again evident that these effects of behaviour, though often apparently negligible and inconspicuous, are of greater ultimate importance than mere mechanical effects. It is behaviour that determines the most vital reactions and their important and far-reaching consequences.

Indeed, the inadequacy of his purely mechanical method was eventually recognised by Spencer. As Principal C. Lloyd Morgan, F.R.S., tells us in his Herbert Spencer Lecture, 1913:—

But in the last edition (*Principles of Biology*, Ed. of 1898, pp. 117, 120) a special chapter is inserted on the Dynamic Element of Life. We here find a tardy recognition of the presence of specific vital characters: "The processes which go on in living things are incomprehensible as the results of any physical actions known to us. . . . In brief, we are obliged to confess that Life in its essence cannot be conceived in physico-chemical terms."

Lloyd Morgan goes on to say:—

I speak of this as a tardy recognition, but it is one that does honour to the man; it is a frank admission that his previous treatment was in some measure inadequate, which a smaller man would not have had the honesty or the strength of character to make. Of course it is traced down to the Unknowable. Life as a principle of activity is unknown and unknowable, while phenomena are accessible to thought

the implied noumenon is inaccessible! Still, certain specific characteristics of living organisms are explicitly recognised as among the accessible phenomena, and these cannot be conceived in physico-chemical terms. But did Spencer fully realise how big a hole this knocks in the bottom of the purely mechanical interpretation of nature he had for so long championed?

It is now sufficiently evident that even without any lifting of the veil concerning the great Unknowable, we have in symbiotic phenomena accessible phenomena of the utmost importance, the study of which must no longer be delayed.

A consideration of those incident forces calling forth the reaction known as heat, leads Spencer on to phenomena that come under the head of nutrition.

Though inanimate bodies admit of being greatly heated by pressure and by the electric current, yet the evolutions of heat thus induced are neither so common, nor in most cases so conspicuous, as those resulting from chemical combination. And though in inanimate bodies there are doubtless certain amounts of heat generated by other actions, yet these are all secondary to the heat generated by the action of oxygen on the substances composing the tissues and the substances contained in them. Here, however, we see one of the characteristic distinctions between inanimate and animate bodies. Among the first there are but few which ordinarily exist in a condition to evolve the heat caused by chemical combination, and such as are in this condition soon cease to be so when chemical combination and genesis of heat once begin in them. Whereas among the second there universally exists the ability, more or less decided, thus to evolve heat, and the evolution of heat, in some cases very slight and in no cases very great, continues as long as they remain animate bodies.

We thus see once again the great superiority of animate over inanimate bodies, in virtue of their character and constitution; themselves the outcome of their evolution. So long as they remain "animate" bodies, they possess a quality of chemical heat-production, not commonly possessed to a similar degree by the inanimate world. They can and must rely upon this quality, which is part and parcel of their endowment, their symbiotics. With any exhaustion of the latter, however, this quality also must needs suffer; and a loss in this direction must become a contributive factor of retrogression and of extinction.

Whether the distinction made by Liebig (Spencer goes on to say) between nitrogenous substances, as tissue-food, and non-nitrogenous substances, as heat-food, be true or not in a narrower sense, it cannot be accepted in the sense that tissue-food is not also heat-food. Indeed he does not himself assert it in this sense. The ability of carnivorous animals to live and generate heat while consuming matter that is almost exclusively nitrogenous, to say nothing of the constant relation above shown between functional activity and the evolution of heat, suffices to prove that the nitrogenous compounds forming the tissues are heat-producers, as well as the non-nitrogenous compounds circulating among and through the tissues. But it is possible that this antithesis is not true even in the more restricted sense. It seems quite an admissible hypothesis that the hydro-carbons and oxy-hydro-carbons which, in traversing the system, are transformed by communicated chemical action, evolve during their transformation, not heat alone, but also other kinds of force. It may be that as the nitrogenous matter, while falling into more stable molecular arrangements, generates both that molecular agitation called heat, and such other molecular movements as are resolved into forces expended by the organism; so, too, does the non-nitrogenous matter. Or perhaps the concomitants of this metamorphosis of non-nitrogenous matter vary with the conditions. Heat alone may result when it is transformed while in the circulating fluids, but partly heat, and partly another force, when it is transformed in some active tissue that has absorbed it: just as coal, though producing little else but heat as ordinarily burnt, has its heat partially transformed into mechanical motion if burnt in a steam-furnace. In such case, the antithesis of Liebig would be reduced to this: that whereas nitrogenous substance is tissue-food both as material for building up tissue and as material for its function, non-nitrogenous substance is tissue-food only as material for function.

The example of the carnivora, as we have seen, fails to provide the criterion of what constitutes wholesome nutrition. That they cannot obtain the right kind of stimulation from their food is, symbiotically speaking, certain.

Spencer omits to note that carnivora rely retrogressively upon those ancestral dynamics (symbiotics) which were at one time characteristic of the whole mammalian order, and therefore are of considerable persistence, although in some instances in course of dissipation. The capacity of chemical heat-production once evolved, like so many other mammalian traits and qualities, is not lost in a hurry, and the getting of

their food also requires at least some (physiologically) wholesome activity, which may aid the digestion of the carbohydrate products of protein metabolism.

That carnivora rarely survive in captivity may be due to the fact that there, owing to lack of exertion, the bad effects of a too exclusively nitrogenous fare become quickly apparent and cannot be sufficiently met by the powers of digestion, by sufficient oxidation and subsequent elimination.

It is all, however, a matter of symbiogenetic adequacy; what is wanted is neither too much nor too little heat, and though we shall agree with Spencer in giving to nitrogenous food a less exclusive position than accorded to it by Liebig, for our criterion of adequacy we shall not be guided by such exclusively mechanical considerations as guided both Liebig and Spencer, and some of our modern investigators. What antithesis exists between nitrogenous and non-nitrogenous matter for physiological purposes must in many cases be utilised in the same way as we saw the milder kinds of antagonism utilised in Nature, *i.e.*, to produce symbiotic and not antibiotic results. It is not nitrogen *per se*, nor carbohydrate *per se*, nor oxygen *per se*, nor heat *per se* that is wanted, but their due proportion to perform in the most efficient manner the work of the world.

Spencer rightly perceives that substances in course of digestion may liberate not only heat, but also other kinds of force; but I would ask whether these are physiological or pathological—symbiotic or antibiotic. He is also correct in saying that this metamorphosis of substances during digestion depends in great part on the conditions; and they in turn depend, as we have seen, on the conditions of domestic and biological symbiosis.

The most modern view is that the metabolism of proteids cannot be separated from that of fats and carbohydrates, and that owing to the action of special ferments, not only can sugars be formed from proteins, but occasionally also proteins from sugars (Abderhalden, Dakin, Cramer). Tissue can thus,

it would seem, be formed by carbohydrates under certain conditions, as Spencer shrewdly foresaw.

The pathogenetic transformation of ancestrally accumulated biological capital, which I assert frequently to occur in Nature, comes out very strikingly in the case of "Phosphorescence," which forms the subject of Spencer's following paragraphs (19, 20, 21).

In some phosphorescent animals inhabiting the sea, as in the *Pyrosoma* and in certain *Annelida*—

Light seems to be really produced, not by direct reaction on the action of oxygen, but by some indirect reaction involving a transformation of force. . . . The re-distributions of matter in general are accompanied by electrical disturbances; and there is abundant evidence that electricity is generated during those re-distributions that are ever taking place in organisms. . . . The special causes of these phenomena have not yet been determined.

Besides these general, and not conspicuous, electrical phenomena, which appear to be common to all organisms, vegetable as well as animal, there are certain special and strongly marked ones. I refer, of course, to those which have made the Torpedo and the Gymnotus objects of so much interest. In these creatures we have a genesis of electricity that is not incidental on the performance of their different functions by the different organs; but one which is itself a function, having an organ appropriate to it. The character of this organ in both these fishes, and its largely-developed connexions with the nervous centres, have raised the suspicion, which various experiments have thus far justified, that in it there takes place a transformation of what we call nerve force into the force known as electricity: this conclusion being more especially supported by the fact that substances, such as morphia and strychnia, which are known to be powerful nervous stimulants, greatly increase the violence and rapidity of the electric discharges.

I have in previous volumes endeavoured to show that in cases of obvious degeneration (through in-feeding) the phenomena of retrograde redistribution of organic matter (pathogenesis) bear a striking resemblance to those of inorganic redistribution of component forces (dissociation) and this under like predicaments, viz., the presence of impurities. In some instances the disintegration may proceed in such sudden and "explosive" fashion as to lead to striking electric phenomena.

Those related to the dissociation of radium may thus be compared to such extreme cases of phosphorescence in the organic world as in some *Pyrosoma* and *Annelida*, and of the explosive discharge of electric (nerve) power as in the Torpedo and in the Gymnotus. In all cases of extreme radio-activity and of phosphorescence, I believe it is the presence of impurities in one form or another which is responsible for the sudden disintegration of previously accumulated forces; violent electric discharges being symptomatic of the pathogenetic utilisation of quondam physiological (symbiotic) forces.

In-feeding or impregnation of animal tissue with inorganic matter thus produces dissociative and generally retrogressive effects, until even special organs may arise appropriate to the continuous metamorphosis of erstwhile symbiotically acquired (nerve) forces into antibiotic (mechanical) forces. Apart from phosphorescence it is in obligate parasites that the "explosive" behaviour of sex strikingly testifies that a pathogenetic momentum of considerable force and beyond all control is reached. The concomitant dependence on a surfeit of nitrogenous food shows that the material for the support of the degeneracy, the "dynamite," has to be abstracted predaceously from strenuous organisms and at the expense of symbiotics. What new organs now arise in furtherance of dishonest living are pathogenetically contrived.

Spencer thinks that "There is abundant evidence that the sensation of taste is due to the chemical actions set up by particles which find their way through the membrane covering the nerve of taste; for, as Prof. Graham points out, sapid substances all belong to the class of crystalloids which are able rapidly to permeate animal tissue, while colloids, which cannot pass through animal tissue, are all insipid."

Again we are thus face to face with the important distinction between crystalloids and colloids, the latter of which we have seen to be possessed of distinct biological character, which is also saying, in other words, that they have a specific

bio-economic part to perform in the web of life. That this part is not the same as that of the crystalloids is evidenced by the fact that they are insipid whilst the latter are "sapid." There is a natural antagonism between the two, but we may conclude that for normal purposes they should not be antagonised to an extreme extent.

If the evolution of taste and of smell is due, as Spencer's passage almost suggests, to the protracted and cumulative inter-action between crystalloid particles and the respective nerve-matter, the question naturally arises which food substances are the most fitted to promote by adequate chemical stimulation the progressive development of these important senses, which are as guides in the selection of foods. Obviously the indispensable nutrition must convey at least a sufficient modicum of crystalloids in some shape or other. At first sight this requirement would seem to clash with the observation that the great bulk of our wholesome natural food is constituted by colloids. The fact that living substance or protoplasm always takes the form of colloidal solution—man himself, like every other organism, being but a complex of colloids—also seems to point in favour of colloids rather than of crystalloids for food purposes. In a colloidal solution, however, as Prof. Schaefer pointed out in his presidential address before the British Association at Dundee (1912), "*the colloids are associated with crystalloids (electrolytes), which are either free in the solution or attached to the molecules of the colloids.*" (Italics mine.)

"In a living substance," he further tells us, "the presence of certain inorganic salts is essential, chief amongst them being chloride of sodium and salts of calcium, magnesium, potassium and iron." . . . "The combination of these elements (their co-operation, as I would add) into a colloidal compound represents the chemical (and incipient symbiotic!) basis of life."

Moreover, we must bear in mind that the most important colloids for purposes of animal nutrition are the so-called *emulsoids* (Emulsion-colloids), a group which in many respects

approaches true, *i.e.*, crystalloid solutions. As Dr. Leiser tells us, these *emulsoids* are "unbegrenzt haltbar," *i.e.*, possess unlimited durability, the artificial or suspensoid (suspension) colloids being far more perishable; and they show at least some osmotic pressure and extreme minuteness of particles (which again differentiates them, rather in favour of crystallinity, from the group of suspensoids or "lyophobic" colloids). The *emulsoids* are more particularly the colloids organised by nature; frequently, as exemplified most prominently by the case of the "love-foods," specially so for food purposes. Significantly the alternative name for these durable and soluble (*i.e.*, hydrophil) *emulsoids* is "lyophil," *i.e.*, solution-loving, which epithet by more than a mere coincidence at once suggests the connection with "love-foods." And thus we see again that it is precisely (symbiotic) cross-feeding (by securing "love-foods") that generally and generously satisfies the highest desiderata as regards the progressive stimulation of the senses of taste and of smell.

No other material provides lyophil ("solution-loving") emulsion colloids in such ideal reciprocity, ideal purity, ideal stability, ideal composition and ideal association with the crystalloid world as the seeds of plants and in general the "love-store" of plants. None other but the plant provides, along with the most appropriate sweet-smelling and sweet-tasting substances, also those liquids (plant-acids) most calculated to ensure the proper composition and equilibrium of the fluids of the body on which much depends in animal physiology. Acetates, tartrates and citrates, for instance, are of great therapeutic use. They play a great rôle in combating the formation of œdema, and are at all times of the utmost importance as regulators of the circulation. The plant not only provides "natural" foods, but also "natural" medicine.

It now appears that the forces which contend against bacterial invasions (antibodies) reside not so much in the serum of the blood as in the red corpuscles themselves, and require for their full development a separation and ionisation of these

corpuscles (Dr. W. E. M. Armstrong). Blood very much diluted thus often has stronger immunising properties than concentrated blood. We may feel sure that it is pre-eminently those viable and symbiotically potent lyophil *emulsoids* which supply the most adequate stimulation, ionisation and nutrition of the red corpuscles without causing undue "ammonisation" (ammonia!) and subsequent proneness to quick decomposition and susceptibility to microbic infection of blood and tissues.

We might, indeed, say that the plant "predigests" inorganic crystalloid material in a manner most suitable for animal physiology, much in the same way as birds will to just a sufficient extent predigest certain foods they bring to their young. *Vis-a-vis* to the animal, the plant really is a transmitter of crystalloid properties, which it slightly modifies so as to render them ideally fit for the special purposes of its biological complement. We have seen to what a startling extent the plant itself depends for its own permanent well-being, survival, and evolution on cross-feeding; necessitating, as we have seen, adequate supplies of mineral salts, *i.e.*, crystalloid solutions.

In view of the apparently well-established fact that in the vegetable world an adequate supply of the earth salts—phosphorus, potassium, iron, manganese, silica, sodium, etc.—acts as a distinct deterrent on parasitic life, and makes for vigorous, virile, disease-resisting, healthy life, may we not assume as much for the animal world?

Thus Dr. H. Packard on "The Possible Factor in the Causation of Cancer," as quoted by J. A. Handy in *The Scientific American*, Oct. 31st, 1914 ("The Principles of Bio-chemistry").

In the same article it is pointed out that the natural mineral salts (in their organic or vito-chemical, *i.e.*, colloidal form) of our food, which were formerly considered more or less unimportant, or secondary in importance to the three main classes—proteins, carbohydrates, and fats—are of the first importance (also as the chief waste eliminators in human metabolism). Mr. Handy, who regards colloids as the allotropic

modifications of inorganic substances, supports the view of Dr. H. Hille that minerals proper, *i.e.*, in inorganic form, cannot be utilised by the human organism as directly and effectually as can true organic minerals; a recognition at which I have also long since arrived.

Although, therefore, free organic crystalloids are rarely to be met with in the animal organism, the latter nevertheless owes a great deal to this agency, powerfully effective as it is through its usual associations with colloidal solutions.

Some organic crystalloids, like grape-sugar, fruit-sugar, and milk-sugar, and certain salts, are indeed temporarily active within the organism in the very crystalloid* form. Further, be it noted—and this is a matter to which we shall have to recur in the next chapter—although it be food in the colloidal stage that is pre-eminently ingested by animals, what is of ultimate and essential use in it has at one stage of digestion to be transformed into the crystalloid phase by ferment-action before it can pass through the membranes within which it finds its preliminary elaboration. Pepsin and trypsin are thus required to reduce (“*ab-bauen*”) many albumens and to transmute them into simpler chemical “individuals” of *crystalloid form*; for instance, into *amino-acids*. In the last analysis, therefore, the importance of the crystalloid phase again becomes emphatic. The colloid aggregate, however, in breaking up, yields to the ingesting animal, apart from the important symbiogenetic charge of its crystalloid element, many residual energies, for good or evil, in accordance with the origin and biological adequacy of the colloid used.

We have already seen that amongst amino-acids it is the *aromatic* ones that are wanted, because of their vitamine association; and when we now find that they are crystalloid and also bear in mind the important relation between crystallinity and the evolution of taste and of smell, we are once more driven to the indispensable conclusion that those “whole” foods alone which embody all the required advantages combined, *viz.*, the “love-foods,” constitute the most ideal, the

most vital and most symbiogenetic food for the animal. And thus with more orientation as regards the relative importance of crystalloid and colloid elements, it will now be easier for us to reconcile some further apparent contradiction concerning the subject, viz., anent the qualities and behaviour of liquid crystals. Their discoverer, Prof. O. Lehmann, has observed a striking analogy between the behaviour of liquid crystals and the characteristics of living matter, so that the designation "apparently living crystals" might in many cases be entirely justified. "Among colloid substances no such analogies exist."

Once more it thus appears that a colloidal solution owes much of its peculiar vital efficiency and "livingness" to its associated forms of crystallinity—though in the liquid state; although it remains to be seen in each case to what an extent this is true. The crystalloid phase seems to involve in pristine purity life forces capable of yielding components which, with adequate use and in due time and season play a regulative part and generally assist, make for symbiogenetic evolution. What is wanted is the gradual establishment of an adequate symbiotic relation with an organic form of life, viz., with a plant cell—we know that different plants "require" different salts—and a progressive synthesis, raising the crystal to the stage of the (symbiogenetic) colloid, can be achieved. Mr. Handy, in his article on Bio-Chemistry, referred to above, puts it thus:—

There comes a time when a portion of the mineral substance is raised to certain ratios of correspondence with the vibratory action of the next higher element of vitochemical life, which appears to lie universally and co-extensively in time and space with the lower element of electromagnetism. When the mineral atom has been thus raised it becomes susceptible to the essence of co-ordination of the higher life element. Impregnation occurs. The vitochemical life element is inducted into mineral substance and the mineral atom becomes a vegetable particle endowed with vitochemical or vegetable life. Is it not reasonable to suppose that by this evolutionary process, guided by Nature's constructive principle, all life is generated upon this planet?

This is a good hint at the principle of symbiogenesis, except that I would put "co-operation" instead of

“co-ordination,” and symbiotic (reciprocal) affinity in the place of mere chemical affinity. At any rate, I would have symbiogenesis comprise chemistry rather than chemistry comprising symbiogenesis.

Mr. Handy speaks of the “Law of Chemical Affinity” as “refining in principle, evolutionary in growth, harmonic in operation, vibratory in activity, and constructive in effect”—in short, as “Nature’s universal formula of evolution,” which is precisely what I claim for the principle of symbiogenesis. To emphasise his “chemical” view, Mr. Handy uses the illustration of the tiny yeast cell. Had he given equal attention to the bio-economic phase of evolution, he would probably have shared my own inclination to attach more fundamental importance to the “personal” than the “chemical” factor. He says:—

Take, for example, one of the simplest forms of vegetable life—the yeast cell. This cell, microscopic in size and possessing the simplest anatomical structure, and consisting simply of a colloidal solution of mineral salts in true organic or vitochemical form, is capable of growth and reproduction, and of carrying out many complex reactions. The yeast cell is capable of elaborating certain nitrogenous colloids called enzymes, or ferments which convert sugar into alcohol, carbonic acid and water. Under certain conditions the yeast cell converts sugar into glycogen, which it may store for a long time within itself, or which it may soon re-convert into sugar and then into alcohol. Under other conditions it may oxidize alcohol. It synthesises protein and cellulose. It forms glycerine, succinic acid, and amyl alcohol. It may reduce sulphur to sulphuretted hydrogen. It generates electricity. It performs, undoubtedly, a whole series of cleavages, syntheses, oxidations and reductions, and yet, examined under the microscope, it appears fairly homogeneous. No structure is visible capable of explanation as to how, in this small space, so many processes can go on side by side in an orderly fashion without interfering with each other.

However interesting the case of the yeast may be, and however beneficial this plant may be in some of its activities (more particularly so when symbiotic with bacteria), the mere illustration of its activities without a detailed bio-economic orientation as regards their value is calculated to over-emphasize the “chemical” factor at the expense of

other equally important factors, and does not conduce, therefore, to a balanced view of life. Wonderful though it is what a simple plant can perform bio-chemically, it is still more wonderful what it normally achieves bio-economically, *i.e.*, symbiogenetically, by its "work"—in virtue of which it enjoys a kind of general sovereignty over properly constituted, *i.e.*, crystalloid inorganic matter.

This, of course, is far better illustrated by the case of the strenuous and clearly progressive (cross-feeding) plants than by that of a unicellular plant of suspect history and doubtful position in symbiogenetic evolution.*

We have seen, as exemplified by the case of the endosperm of Indian corn and fruits in general, that "love-foods," over and above their vitamine endowment, are characterised by an extraordinary degree of "livingness," in virtue of their symbiogenetic mode of origin, or, as we might also say, in virtue of the biological impress they bear. If they are specially "organised," it is that in their production the biological factor has been more specially at work. If they are specially efficient, it is that a most concentrated symbiogenetic process—the "alchemy" of fertilisation (and what it entails in previous efforts) has been instrumental in their production.

When so much is thus everywhere due to the biological ("personal") factor, the proposition that the crystalloid world is instrumental in the evolution of certain animal senses almost requires the postulate of a considerable degree of "livingness" in the crystal, which postulate Prof. Lehmann's researches, and many others on the subject of crystallinity, would indeed seem to necessitate.

The further inference from such considerations is that we

* The yeast, of course, belongs to the vast group of the Fungi, the frequent degeneration of which we have already considered. Although the physiology of the fungus-cell is not fundamentally different from that of ordinary plant-cells, it is deficient in that most important function of photosynthesis, and, consequently, as we have already seen, saprophytism and parasitism are especially pronounced amongst Fungi. To what an extent the yeast must be considered as a degraded form, has not yet been definitely determined.

shall look increasingly to biological factors, such as reciprocal differentiation, for purposes of discrimination, *i.e.*, determination of the biological adequacy of food substances. "Love-foods" are so ideally organised that their energies are capable of being transmitted in the most beneficial and direct manner to the animal; whilst colloids not specially organised frequently can be assimilated only indirectly, partially and precariously, leaving dangerous residual energies, which prove a disturbing factor in the physiological economy and integrity of the animal. A somewhat similar sequence obtains in the nutrition of plants. They suffer as soon as the principle of symbiotic feeding is seriously infringed.

The next chapter will provide ample evidence to show the danger of food residues and the injuriousness of certain groups of colloids; as detrimental as many crystalloids or alkaloids, such as are not specially organised for food, but often indeed for quite opposite purposes, *i.e.*, prevention of ingestion.

Our position as regards "in-feeding" is thus becoming increasingly clear. Evidently indiscriminate use of colloids, as here involved, cannot have the same beneficial effects on the developments of taste and smell, or as regards possibilities of metabolic response as has cross-feeding.

That in the case of in-feeders the prevailing diathesis and failure of stimulation of important nerve centres may easily concur to facilitate pathogenetic transformation of nerve-force into electricity now becomes much more evident. Electric fish, like the *Torpedo* and *Gymnotus*, represent a "pathogenesis" which is the reverse of symbiogenesis. The facts are easily interpreted on my diagnosis. To satisfy their morbid feeding habits, all that these animals require is an occasional sudden pathogenetic production of force. This is possible so long as they can precariously replenish their losses by what I call ill-gotten gains of "explosive" substances.

It is also clear that with increasing indulgence morbid cravings must increase rather than otherwise, and that in such cases quantities excessive for ordinary physiological purposes

are being ingested. Just as great quantities of ore have to be treated to yield a trace of radium, so, with morbid appetites, large amounts of food have to be metabolised in order to obtain a modicum of the substances indispensably required, all of which goes on at the expense of evolution. Experiments have shown that rats fed on vitamineless diet will feed as voraciously as those fed on a vitamineous diet. No doubt the craving for what is really wanted (*i.e.*, the ideal vitamine-content of the "love-foods," missing in other fare) in many cases induces a great deal of voraciousness and of over-feeding with further pathological results.

The general habits of in-feeders, moreover, do not involve exertions systematic enough to lead to progressive physiological development; they only involve casual and non-reciprocal exertion, or as in the case of the *Torpedo*, only casual "explosions." That there are such pathogenetic possibilities of "specialisation" is interesting, but the transformations are not permanently satisfactory and eventually lead to failures. The monstrous appearance of the *Torpedo* and the generally huge size of the electric organ are significant symptoms of abnormality and of biological antithesis.*

These electric phenomena, be it noted, are manifested by animals which practise in-feeding, and the electric organs are used for killing prey or assisting in its capture.

The fact noted by Spencer that substances, such as morphia and strychnia, "which are known to be powerful nervous stimulants," greatly increase the violence and rapidity

* In my opinion such monstrosity represents one form of nemesis resulting from an in-feeding diathesis and is well on the road to physiological and biological isolation and to extinction as instanced by the monstrous marine reptiles and the heavy flightless birds of old and the *Cetacea* of the present. All well-made fish weigh, in equal bulk, just as much as water (Houssay). When very sluggish and parasitic, however, they are badly shaped, too long or too short, and decidedly heavier than others or the water. Although in the intermediate or degenerate stage some predaceous fish are good swimmers and comparatively well shaped, many, as we have seen, are subject to a reproductive nemesis, whilst a more purely biological nemesis becomes emphatic from recent helminthological research (Dr. W. Nicholl) showing an enormous incidence of parasitic infection in the intestines (81% with parasites of over 50 different species—flukes, tapeworms, threadworms, etc.). We shall presently see that such infection is apt to impair the "hosts" bio-chemical system and to stimulate pathological increase of size.

of the electric discharges, is also, I believe, of peculiar significance with reference to my generalisation that nature abhors perpetual in-feeding; because antagonistic to the law of symbiogenesis.

That the peculiar relation between particular substances, especially plant substances, and particular parts of the animal nervous system, are of evolutionary origin and evolutionary significance, can now no longer be doubted. It is futile to treat the oft-times appalling potency of the plant alkaloids on animal physiology as a mere local matter. These alkaloids, in my view, are the expression of a deep-seated antagonism of the plant world to animal depredation. C. Simmonds points out the following in *Nature* (21/8/13):—

The alkaloids of plants have long offered a most interesting and attractive, if always difficult, field of research to both chemists and physiologists. The subtle chemistry of the vegetable cell evolves no objects more fascinating to study than these "vegetable alkalis" as Sertürner first termed them.

When, however, the chemical structure of an alkaloid has been elucidated, there yet remains a problem of great general importance, namely, how its chemical constitution is correlated with its action on the animal system. What is the deft arrangement of atoms which confers upon strychnine its tetanising action, convulsing all the muscles of the body; and what, on the other hand, is the arrangement in curare, a drug which paralyses the motor nerve endings without affecting the excitability of muscle? Many useful observations have been made on this question, but the difficulties are great, and progress slow. A comparatively simple case is quoted where two investigators, after studying the relation between the mydriatic action and the chemical constitution of the tropëines, were forced to the conclusion that no generalisation could be made which would explain all the results they obtained.

Another question which has been much debated is the mode of formation of the alkaloids in the plants. The view mostly favoured is that they, or at least some of them, are decomposition-products of proteins, chlorophyll, and other complex substances. As regards their function in the plants, they have been variously considered as nutrient materials, protective substances, or end-products of metabolism, rendered harmless to the plant and stored chiefly in special cells whence they are not readily re-absorbed into the active plant tissues.

The generalisation that appears most apposite, though it is frequently overlooked, is that there is scarcely any important development in the plant world that has not some reference to the animal as its physiological complement in biological symbiosis; and we may fairly infer that similarly all important developments and susceptibilities that we find in the animal world must have some reference to the connected flora, past or present.

My view is that these terribly potent vegetable alkaloids are protective in the same way as thorns and other defensive contrivances, and that they tend to restrain the animal from destructive depredation and thus afford a striking case of Nature's safeguarding contrivances calculated to uphold an efficient biological symbiosis, *i.e.*, subservient to symbiogenesis. The measure of their appalling potency is also a measure of the marvellous, though less conspicuous, wholesome properties of plant substances under due relations of symbiosis.

Again we may thus apply the maxim, *Pathologia physiologiam illustrat*. It is quite possible that these vegetable alkaloids are formed from primarily "nutrient materials" or "end-products of metabolism," which but for their diversion for this defensive end would normally go to sustain not only the plant, but also some animal; they would then be as physiologically adequate, as they have now, owing to abuse, been rendered not only inadequate, but actually poisonous. Prof. Schaefer likens the effects of hormones to those of the vegetable alkaloids, and Dr. Funk regards the vitamins as the mother-substances of ferments and of hormones, all of which seems to support my proposition.

It is significant in this connection that sometimes the plant—which, by the bye, is the richer and healthier for what is legitimately taken from it—seems to divert its poisonous contrivances very evidently against the predaceous animals only, whilst remaining a source of sustenance to the non-predaceous.

Thus according to Kerner:—

The foliage of the Deadly Nightshade is a poison to the larger grazing animals, and by them is left undisturbed; but the leaves of this plant are not only non-poisonous to a small beetle (*Haltica Atropæ*) but form this animal's most important food. The larvæ of this beetle often eat numerous holes in the leaves, which, however, by no means prevents the development of the Deadly Nightshade. Accordingly the leaves are protected by the alkaloid contained in them only against wholesale extermination; limited portions of them can be surrendered and sacrificed with impunity.

The term alkaloid is now generally restricted to bases of vegetable origin and characterised by remarkable toxicological effects. It is again significant that such bases occur almost exclusively in the dicotyledons, and generally in connection with malic, citric, tartaric or similar plant-acids. Thus we see that those types of plants which rank highest in the production of "love-foods" and in productiveness generally, are also particularly characterised by capacity for alkaloid productions, *i.e.*, the alkaloid production is associated with strenuousness, and again is seen to be an instrument for protecting wholesome symbiosis. In a similar way the rose has its spines and the bee its sting, and we saw that the cultivated bee in obedience to symbiotic principles is willing to forego some of the surplus honey for protection afforded, but resents rank exploitation. Like the useful plant it has evolved a poison as a means of assuring the security of its industry. It is perhaps worth adding here that, just as I consider strenuousness and cross-feeding as primitive, so, it seems, there is evidence to show that dicotily is a primitive character, and, further, that trees and shrubs are primitive as compared with herbs among flowering plants. It all points to ancestral dynamics, *i.e.*, symbiotics as I have depicted them, as the prime requisites and the primary features of healthy (physiological) life.

Given normal relations, the plant offers mild stimulations together with its "love-foods" and those subtle substances which are so vitally important in nutritional and hence also

sexual amphimixis. In short, we may repeat that when the normal biological relations become distorted, much that was previously wholesome may be, and often is, turned into poison. The law of conflict becomes the alternative of the law of symbiosis.

Let us remember the extraordinary symbiotic value of so mild a plant secretion as honey in the evolution of the hymenoptera, and through them upon evolution in general. Let us remember that felonious ways of obtaining the honey react damagingly upon the bees and bring other undesirable correlations in their train. Seeing how much depends on the proper constitution and balance of protein and other complex and indispensable substances for the manufacture of which the plant alone possesses the secret, it stands to reason that any conduct on the part of an animal calculated seriously to interfere with the plant's general welfare and productiveness may easily and almost automatically tend to interfere with and to distort the beneficial composition of the plant's products. From the manufacture of a wholesome proteid to the production of a poisonous alkaloid, therefore, may not be a long step.

If a green tobacco plant is inoculated with various organic compounds, the proportion of its nicotine output may be doubled, which shows that anything that tends to lower the efficiency of the photosynthetic output of a green plant tends to render the plant more negative in symbiogenetic value generally, *i.e.*, in this case more poisonous. It is known that several families of plants produce free prussic acid. They are called *Cyanogenetic* plants, and animals rarely touch these plants. *Knowledge* (Sept., 1914) reports that according to Jorissen (Bull. Acad. Roy. Belg., 1913), the most recent investigator of this subject, this acid (prussic) results not only from the process of carbon assimilation, but also from the action of *Nitrogen* compounds upon substances as vanillin and citric acid. "For instance, if a mixture of citric acid with a much smaller amount of potassium nitrite and a trace of bicarbonate of iron be exposed to light in a glass vessel for a

day, the latter being open and kept at the ordinary temperature, hydrocyanic acid is formed." Again we may infer that a metabolic disturbance—in particular, surfeit of nitrogen (in-feeding)—is apt to diminish the bio-chemical and bio-economic value of plants.

We have already referred to the fact that it is only when put together in certain proportions that sulphur, charcoal, and nitre produce explosives which may have devastating effects. In other proportions they are calculated to fertilise the soil and to feed populations, and it is the quasi-symbiotic relations subsisting between nations that determine whether the particular materials shall be put to fruitful or frightful use, whether they shall help to feed and fertilise or devastate and destroy. In all cases it is the matter of mutual relations that determines effects and values.

It is remarkable that the toxicological effect of many plant alkaloids is especially marked upon the respiration of animals (see example of *Coriamyrtin* and *Tutin*, British Association Report, 1912, p. 643), and when we remember the importance of respiration in biological symbiosis, we may again say that the plant here effects pathologically (by extreme stimulation) what in normal relations it effects physiologically (by mild stimulation), *i.e.*, normal respiration is based on undisturbed symbiosis.

It is similar in the allied case of circulation, on which so much depends in life and in evolution. Darwin, as we have seen, mentions in the *Origin of Species* the belief held by physiologists that "the brain must be bathed by warm blood to be highly active, and this implies aerial respiration."

He omits, however, entirely to consider to what an extent both circulation and respiration depend on biological symbiosis. (That they do so depend, and this very importantly, we have already inferred in this and in the first chapter).

He concludes that "warm-blooded mammals when inhabiting the water lie under a disadvantage in having to come continually to the surface to breathe." This is, indeed, what

may be termed a mechanical disadvantage; but it is rather an evolutionary disadvantage of which the above is only a concomitant, and it has been brought about by the predatory habits which have driven these mammals to an aquatic life with consequent surrender of biological symbiosis as carried on by biologically useful animals, and some of them, *e.g.*, the whales, just like certain monstrous terrestrial carnivora, have grown body and digestive apparatus antithetically to brain—an antithesis which is the natural outcome of their bio-economic retrogression. The reason why there is such a great blood supply to the grey matter of the brain," Dr. F. W. Mott tells us, "is that important bio-chemical processes occur there, constituting the physiological basis of mental activity." All "supply," however, is in the long run conditional upon symbiosis, and if in the case of the monstrous carnivora^s (suffering from a long-standing diathesis), eventually the brain shrivels, we must conclude that their vital Bio-Chemistry has deteriorated *pari passu* with the growth of their antibiotic behaviour. Experimental verification of the fact that the ingestion of inappropriate nitrogenous food materials has decided pathological effects upon the brain will be forthcoming in the next chapter. It is true Darwin concedes that a carnivorous quadruped may better succeed in survival by "becoming less carnivorous," which we found indeed paralleled by the case of the *Convoluta* and of *Dendrocygna*, although Darwin only refers to the greater possibilities of food-supply (when not too strictly limited to flesh food), and seems scarcely aware of the wider (symbiogenetic) application of his statement.

On the other hand it is among symbiotic cross-feeders (*i.e.*, non-parasitic vegetable feeders), aided by the forces of biological symbiosis, that we find striking evidences of the evolutionary ascent from aquatic to aerial respiration. The amphibians figure very conspicuously in this category. We have in the tadpole, feeding chiefly on algæ, an instance of a survival of cross-feeding habits which must have been largely responsible in the past for the production of that physiological

super-adequacy of force sufficient to accomplish a great step forward. The ideal adequacy of properly matured plant-food in animal economy is, of course, primarily and directly to be inferred from its physiological good effects; but we may also infer it indirectly from the inadequacy of a heterogeneous albuminous diet and its immediate and more remote pathological effects.

If the effect of such alkaloids as *Tutin* and *Coriamyrtin*—though of vegetable origin—upon frogs is such as to lead to an extreme of respiration (combined with muscular stiffness, sluggishness and in-coordination of movement, and later convulsions), this is so because they are evolved for a special, *i.e.*, preventive purpose. The example merely emphasises that the adequacy of food is determined by bio-economic factors, and that for a genuine cure of an in-feeding diathesis we should have to have recourse to normally evolved plant substances by means of which to redeem the bad currency and to restore the possibilities of generally wholesome correspondence.

Such plant substances having been “proved,” as homœopathy would say, upon healthy individuals, should also be of considerable efficacy in cases of disease, provided the cure is to consist of a genuine reconversion. The homœopathic maxim, *Similia similibus curentur*, *i.e.*, similars should be treated by similars, resulted from the observation of the great potency of some vegetable drugs which invited the inquiry as to whether they might, by appropriate means, be shorn of their extreme effects and reduced to yield an erstwhile innocent and beneficent action upon human physiology. Disease, amounting in reality to a distortion of symbiosis, the problem before homœopathy is to cure by doses of vegetable extracts which in their very mildness of stimulation resemble the normal symbiotic stimulation exercised by plant substances, and thus conduce to better conditions of health. Homœopaths eschew extreme doses, but first “potentize” them. It was thus by a kind of intuitional comprehension of what was lacking that the

mild (similar, but reduced or reversed) stimulations (like those of plant-food itself) appealed to the pioneers of Homœopathy. How far these stimulations are justified in every individual case, and how far they require to be complemented by a well-balanced (cross-feeding) dietary, in order to produce permanent good effects, of course remains to be seen in every case. The real aim of therapeutics must always be to effect a physiological re-conversion and not merely a suppression of symptoms.

J. A. Handy, Ph.C., B.S., Phar.M., whom I have already quoted, is of opinion that if the physician can control nutrition he can control disease. (*Scientific American*, 31/10/14.)

It is significant in this connection that, as pointed out by Prof. Schäfer at the International Medical Congress, London, 1913, the important internal secretions of the body, which are now being more widely studied, are in their action similar to that produced by the active principles of drugs, “especially by those of *vegetable* origin.”

Again this points to the fact that the vegetable kingdom is the real source of all valuable stimulations, as it also simultaneously provides the most valuable food substances and the important connected principles. We have seen that Dr. Funk regards the vitamines—the subtle and highly complex substances of vegetable origin indispensable to animal nutrition—as the mother-substances of ferments and hormones. Again we may infer that the (symbiogenetic) evolution of the glands concerned in animal metabolism was in great part due to stimulations derived from vitamines, and that these glands have specialised as storers of the valuable energies carried by the vitamines. It was pointed out by Prof. Abderhalden (*Lancet*, 13/9/13), in his paper on the formation of specific ferments which deal with toxic substances in the blood, that the presence of such ferments might be taken as demonstrating the presence of the substance to which they corresponded. In a similar way we may say that the presence of certain specific glands, such as the thyroid and other ductless glands, to which

the vitamines are of vital importance, demonstrates that their business has always been to deal with the corresponding substances, and that hence their evolution was the result of a long-continued ingestion of appropriate (*i.e.*, biologically reciprocal) food. We can thus understand the similarity of stimulation by certain internal secretions of the body to that exercised by certain vegetable drugs, for the stimulations are essentially of the same nature. We can also understand how it is that mild doses of certain vegetable extracts may be useful in restoring a better physiological balance.

As we have already seen in the case of the evolution of the mammary gland and of the *corpus luteum*, they have arisen symbiogenetically *pari passu* with increasing productiveness, increasing symbiosis and increasing complexity of the web of life.

The product of the mammary gland is milk—a “love-food” of the first order. “Le lait, bien qu’ élaboré dans le corps de l’animal, est une substance végétale,” says Rousseau. It is worth noting in this connection that milk bears striking similarities to another kind of “love-food,” the symbiogenetic importance of which (particularly in connection with mammalian evolution) we have already noted, *viz.*, nuts. Nuts are exceedingly rich in fat which (like that of milk) is already in a state of emulsion, *i.e.*, ready made (prepared or pre-digested, as it were) for circulation through the lymphatic system. Nuts also contain a high percentage of albumen which is easily assimilable and does not form uric acid, *i.e.*, they contain albumen that lends itself to symbiogenesis rather than to pathogenesis. Whilst fairly rich in carbohydrates (starch and sugar), nuts are three to four times richer in vitally important mineral salts than animal flesh and even milk. The medicinal properties of many nuts have been well recognised. Cocoanut-milk, indeed, very appropriately reminds us of the reality of the symbiogenetic importance of nuts in particular and of “love-foods” in general.

Hormones and chalones may be said to be the ultimate agents of animal form in virtue of their evolutionary history, *i.e.*, the symbiogenetic evolution of plant and animals themselves. The share of the plant-world in this history must have been very great. That the general effect of plant food in the "digestive transformation" of animals is wholesome and duly restraining, whilst flesh foods are accelerating and disintegrating in their effects, I believe I have to some extent demonstrated in previous volumes. I have spoken of "katabolic emanations," meaning thereby the decomposing (inductive) effects of flesh foods (as provided by perpetual in-feeding) and their unduly accelerating effects upon growth as compared with the mild physiological or "anabolic" effects of plant-food which restrains over-activity on the part of the animal. The colloid organised by the plant for animal food having once yielded its symbiogenetic (reciprocal) growth-tendencies to its complement organism, becomes itself transformed into an animal colloid and, for therapeutic purposes, from an anabolic into a katabolic agency. The energy which it is now capable of yielding in great part is anything but symbiotic, but tends instead to determine the evolution of the ingesting organism along particular and "peculiar" lines, *i.e.*, mostly retrogressively. The erstwhile symbiogenetic polarity is distorted by non-reciprocal influences emanating from the tissues of the devoured animal.* Cancerous tissue (a good example of morbid colloidal antagonism, of intense histological in-feeding with frequently such stimulants as choline and cadaverine) is known to retain some of the growth tendencies of the organ in which it originated, and in a similar way the ingestion of animal tissue tends to impart its own (katabolic) tendencies to another animal.

* It is known that a veritable bio-chemical system is involved in the co-operation of the various glands of the body, and that excessive secretion of some glands during growth leads to gigantism, excessive secretion after maturity to acromegaly, whilst insufficient secretion produces excessive deposition of fat and atrophy of the genital glands. What is ignored, however, is that in this glandular interaction the law of conflict becomes the alternative of the law of co-operation for the same reason as in the wider biological sphere—*viz.*, transgression against symbiogenesis.

And thus we obtain further explanation of the extreme cases of sexual dimorphism and of that remarkable abnormal increase of size in certain types during palæontological periods, which we have already set down to the cumulative effects of anti-symbiotic forces liberated by food substances obtained otherwise than by a due (biological) reciprocal differentiation. The study of surface-energy shows that the discharge of ions of various direction by the minute colloid particles of our food is indeed a most important and (in the long run) determinant factor. Plant and animal being biological (and chemical) opposites, it easily follows that there is normally a corresponding difference of charges—anabolic and katabolic—in their constituent particles. A normal colloidal charge would direct an organism symbiotically; the cumulative effect of undesirable components in colloidal charges is to determine the organism pathogenetically, with varying effects upon form. Frequently, when opposing pulls of this kind are present, the equilibrium struck by the species frequently is one represented by sexual dimorphism—antithesis of form in male and female—and likewise by an antithesis of form as against the *normal* biological kin of the species, *i.e.*, those that have remained symbiotic and cross-feeding, and therefore do not present dimorphic or monstrous (“teratological”) developments.

To return now to Spencer. Considerations of “nerve-force” and its genesis involve him in considerable difficulties which his physico-chemical method is apparently unable to solve.

Heat, light and electricity are emitted by inorganic matter when undergoing changes, as well as by organic matter. But there is a kind of force manifested in some classes of living bodies, which we cannot identify with any of the forces manifested by bodies that are not alive—a force which is thus unknown in the sense that it cannot be assimilated with any otherwise recognised class. I allude to what is called nerve-force.

This is habitually generated in all animals, save the lowest, by incident forces of every kind. The gentle and violent mechanical contacts, which in ourselves produce sensations of touch and pressure

—the additions and abstractions of molecular vibration, which in ourselves produce sensations of heat and cold, produce in all creatures that have nervous systems certain nervous disturbances—disturbances which, as in ourselves, are either communicated to the chief nervous centre, and there constitute consciousness or else result in merely physical processes that are set going elsewhere in the organism. In special parts distinguished as organs of sense, other external actions bring about other nervous re-actions that show themselves either as special sensations or as excitements which, without the inter-mediation of consciousness, beget actions in muscles or other organs. Besides neural discharges that follow the direct incidence of external forces, there are others ever being caused by the incidence of forces which, though originally external, have become internal by absorption into the organism of the agents exerting them. For thus may be classed those neural discharges that from moment to moment result from modifications of the tissues wrought by substances carried to them in the blood. That the unceasing change of matter which oxygen and other agents produce throughout the system, is accompanied by a genesis of nerve-force, is shown by various facts—by the fact that nerve-force is no longer generated if oxygen be withheld or the blood prevented from circulating; by the fact that when the chemical transformation is diminished, as during sleep with its slow respiration and circulation there is a diminution in the quantity of nerve-force; in the fact that an excessive expenditure of nerve-force involves excessive respiration and circulation and excessive waste of tissue. To these proofs that nerve-force is evolved in greater or less quantity according as the conditions to rapid molecular change throughout the body are well or ill fulfilled, may be added proofs that certain special molecular actions are the causes of these special re-actions. The effects of alcohol, ether, chloroform, and the vegeto-alkalies, put beyond doubt the inference that the overthrow of molecular equilibrium by chemical affinity, when it occurs at certain places in the body, results in the overthrow of equilibrium in the nerves proceeding from these places—results, that is, in the propagation through these nerves, of the change called a nervous discharge. Indeed, looked at from this point of view, the two classes of nervous changes—the one initiated from without and the other from within—are seen to merge into one class. Both of them may be traced to metamorphosis of tissue.

Thus we see that systematic contact with the external world and the necessity to vibrate, as it were, in tune with the biological world—le besoin, père de l'adresse—*plus response* from within, may be said to be responsible for the genesis of the nervous system and so of organic consciousness. It is clear

that something besides mere physico-chemical factors is here concerned, and I agree with Principal Lloyd Morgan in his remarks on the correlation of external and internal relations in his Spencer Lecture (1913). This is what he has to say:—

There occurs let us say, an external event in the physical world, such as the motion of a billiard-ball across the table and, when, during its progress, this stimulates the retina, there is an internal physico-chemical process which runs its course in retina, optic nerves, and the central nervous system. We may regard these two processes—external and internal—as so far of like physical order. With adequate knowledge the two could in some measure be serially correlated as such. But the physico-chemical processes in the organism are not only of this physical type. They are vital or physiological as well. And this makes a real difference. Of course this statement is open to question. But I, for one, believe that there are specific relations present in physiological processes *quâ* vital, other than those of the physico-chemical type—relations which are effective and which require a distinctive name. So far I am a vitalist. At some stage of evolution these new modes of effective relatedness came into being, whereas in the fire-mist and for long afterwards they were not in being. None the less when they did actually come into being, under conditions of which we are at present ignorant—though not so ignorant as we were—they were dependent upon and, for our interpretation, they logically imply, the physico-chemical relations which are also present. In any case they further imply, through heredity-relatedness, the evolutionary history of the organism in which they obtain. This so-called historical element in biology no doubt involves a characteristic vital relationship. But, I take it, the physico-chemical constitution of any inorganic compound, and of any molecule therein, has also its history—has relationship to past occurrences within its type, which have helped to make it what it is. Still, in the organism the relation to past happenings has a quite distinctive form which we deal with in terms of heredity.

Evidently, as Prof. Lloyd Morgan recognises, the whole matter is very complex, and it is as difficult to say whether a purely vitalistic impulse or a physico-chemical first started life, as it is difficult to determine which was first, the egg or the hen. It may be that the very first impulse was a dual impulse in which both psychical and mechanical forces were blended. It does not, however, affect our bio-economic argument in the least, whether the mechanistic or vitalistic view

should finally prove correct.* Enough for our purposes that physiological order exists and requires recognition as differentiated from purely physico-chemical order. Enough that the internal and the external are inter-related or have in course of time become related though differentiated. Enough that aspects of behaviour and of economics are the more important the more we find the inter-dependence of life to have progressed.

Whether an organism has a nervous system and is conscious of what it does or not, matters comparatively little. What matters more is that it becomes an active participant in the business of life. Vivre, ce n'est pas respirer, c'est agir. So long as an organism works, it may do so without, or with only an equivalent of, a nervous system. Spencer's remarks go a long way to show that the genesis of a nervous system depends on metabolism and on mobility (circulation), and hence on work and on division of labour, and generally on systematic bio-economic conduct. Excessive expenditure of nerve-force involves excessive waste of tissue. This is true, and it might be due, amongst other factors, to "over-work." In the majority of cases, however, and this is what Spencer has overlooked, waste of nerve-force and correlated loss of tissue and of structure is due to the other extreme, viz., cessation of work and consequent loss of symbiotic relations. Spencer, usually so fertile in illustrations, here signally fails to provide a good instance of nerve and tissue degeneration, although they abound in nature. Apparently we are to be satisfied with certain clinical observations and with the illustration drawn from sleep. But an animal like the *Ascidian*, for instance, which surrenders typical activity and becomes fixed on the soil in order to batten without toil on the offal of life, is like an organism in perpetual sleep and suffers a most drastic degeneration of the nervous

* Here I am inclined to agree with Mr. O. W. Griffith (*Hibbert Journal*, January, 1915): "The real issue is not between monism and dualism, or between vitalism and mechanism. The real issue is between the cramped confines of a formula and the ever-widening comprehensiveness of a philosophy. It is true of life, as it is true of the whole universe, that its greatness is manifest only in its wholeness—its unifying totality."

system as a consequence. That is to say that activity, *i.e.*, work, is a necessary condition of the maintenance of status.

As regards the overthrow of the nervous equilibrium by vegeto-alkalies, we have previously seen that we have here not merely "special molecular actions," but that symbiotic factors are fundamentally concerned. In short, whether "the conditions of rapid molecular change throughout the body" are well or ill-fulfilled depends entirely on biological factors. If this is true of so many kinds of "insensible motion," it is far more true of "sensible motion."

"It is indeed usual," continues Spencer, "to regard the power of generating sensible motion as confined to one out of the two organic sub-kingdoms; or, at any rate, as possessed by but few members of the other. On looking closer into the matter, however, we see that plant-life as well as animal-life is universally accompanied by certain manifestations of this power; and that plant-life could not otherwise continue."

This he infers from the facts of "an internal transposition of parts" in plants and of "the mutual dependence of organs having unlike functions," and of the "shooting out of pollen by some flowers on to the entering bee when its trunk is thrust down in search of honey," *i.e.*, from obvious symbiotic arrangements. Hence he thinks that on the production of this "mode of force" (*i.e.*, "sensible motion"), more especially depends the possibility of all vital phenomena. The power of "sensible motion" is thus seen to be identical with the general power to be symbiotic.

Spencer is satisfied that his study of the reactions of organic matter on forces has yielded the result he required, *viz.*, the confirmation of one of his physico-chemical *First Principles*: the persistence of force.

Whatever amount of power an organism expends in any shape is the correlate and equivalent of a power that was taken into it from without. On the one hand, it follows from the persistence of force, that each portion of mechanical or other energy which an organism exerts, implies the transformation of as much organic matter as contained this energy in a latent state. And on the other hand it follows

from the persistence of force that no such transformation of organic matter containing this latent energy can take place without the energy being in one shape or other manifested.

This is all quite true. But, as we have now sufficiently seen, it is but a partial truth, and the principles of Biology can only be very partially understood without the recognition of Bio-Economics.

D.

As regards the

"PROXIMATE DEFINITION OF LIFE"

(the subject of his next chapter), Spencer starts by putting us on our guard against the fallacies of classifications which, as he says, are subjective conceptions, "which have no absolute demarcations in Nature corresponding to them."

Schelling's definition of Life, that it is the tendency to individuation, is rejected on the ground that it includes under the idea of Life much that we usually exclude from it: for instance, crystallisation. This objection, however, appears no longer tenable in the light of recent science. When we consider, for instance, such phenomena as Prof. Stephane Leduc's osmotic growths, showing that faculties of nutrition, absorption, elaboration or chemical metamorphosis, assimilation, elimination, growth, development, functional differentiation, organisation, inanition and disease are not absent in the inorganic world, we find that our classification of things into living and non-living is inadequate, and that, in Spencer's own words, it is a case of our definition "leaving out something that should be taken in."

Schelling's definition, therefore, seems fairly satisfactory and intelligible. It is congruous with Dr. J. S. Haldane's conception of "personality" (or "character," as I would say) as the great central fact of the universe.

Spencer thinks that a definition supplied by himself, "the co-ordination of actions," answers the facts with "*tolerable*" precision.

It includes all organic changes, alike of the viscera, the limbs and the brain. It excludes the great mass of inorganic changes which display little or no co-ordination. . . . By making co-ordination the specific characteristic of vitality, it involves the truths, that an arrest of co-ordination is death and that imperfect co-ordination is disease. Moreover, it harmonises with our ordinary ideas of life in its different gradations: seeing that the organisms which we rank as low in their degree of life are those which display but little co-ordination of actions, and seeing that from these up to man the recognised increase in degree of life corresponds with an increase in the extent and complexity of co-ordination.

But "co-ordination," however congruous with Spencer's *First Principles*, and however convenient in purely physico-chemical biology, does not quite answer.

But, like the others, this definition includes too much; for it may be said of the Solar System, with its regularly recurring movements and its self-balancing perturbations, that it also exhibits co-ordination of actions. And however plausibly it may be argued that, in the abstract, the motions of the planets and satellites are as properly comprehended in the idea of life, as the changes going on in a motionless, unsensitive seed; yet, it must be admitted, that they are foreign to that idea as commonly received, and as here to be formulated.

Obviously "co-ordination" should be replaced by "co-operation," a word which is far more inclusive, though still in a sense applicable also to the Solar System.

That symbiotic activity tends towards increased individuation, we have seen, and Schelling's definition would thus not be invalidated. "Co-ordination," however, is neither flesh nor spirit, though it is a convenient term.

We have previously seen that Spencer is elsewhere driven to postulate "co-operation" and to admit that biological facts must be interpreted "in some such way," although, this being admitted, he stated we can only "dimly discern a harmony with first principles." Indeed, in the very chapter on the "Proximate definition of life," he says that: "It needs but to contrast the many organs co-operating in a mammal, with the few in a polype, to see that the actions which are progressing together in the body of the first, as much exceed in number the actions progressing together in the body of the last, as

these do those in a stone." Thus we see that it is co-operation rather than co-ordination that is the test of status and of degrees of life. Co-operation includes co-ordination.

What "is co-ordination of actions" if it is not co-operation? If it is not to be co-operative, then, as Spencer rightly perceives, an organism becomes a brother of the sun and of the stars which implies a consanguinity, if one may say so, which seems rather remote. Co-ordination, therefore, takes us too far out of our sphere and into cosmic realms where we yet lack a compass, where, as Goethe would say, we meet with spirits that we do not comprehend for lack of similarity. It is otherwise with co-operation, which moves in spheres that we can understand and explain with tolerable adequacy, and tolerable consensus of opinion. "Die Erde hat mich wieder."

With "co-ordination" we have the physico-mechanical Spencer. As Professor Lloyd Morgan rightly says of him:—

The impression one gets, here and elsewhere, is that all forms of relatedness must somehow, by the omission of all other specific characters, be reduced to the mechanical type. This, no doubt, is unification of a sort. But is it the sort of unification with which a philosophy of science should rest content?

It may be said that unification can only be reached by digging down to some ubiquitous type of relation which is common to all processes throughout the universe at any stage of evolution. But what, on these terms, becomes of evolution itself as a problem to be solved? Surely any solution of that problem must render an account of just those specific modes of relatedness which have been ignored in digging down to the foundations. Surely there must be unification of the superstructure as well as of the substructure. Here and now is our world within the texture of which things stand to each other in such varied relations though they may be reducible to a few main types. There, in the far-away past, was the primitive fire-mist, dear to Spencer's imagination, in which the modes of relationship were so few and so simple, and all seemingly of one main type. How do we get in scientific interpretation from the one to the other? Will it suffice to breathe over the scene the magic words differentiation and integration? Spencer appears to think so. Of course he did exceptionally fine work in eluci-

* The word co-operation has hitherto been tabooed or argued out of existence by biologists, because there was no theory of co-operation. The word competition has, however, been welcomed universally, because there was an established theory of competition. Such dialectic opposition to the introduction of a theory of co-operation has too long been the bane of progress.

dating the modes of differentiation and integration within certain relational fields—though he sometimes uses the latter word for mere shrinkage in size. But what one asks and asks of him in vain, is just how, within a connected scheme, the several relational fields in the domain of nature are themselves related, and how they were themselves differentiated.

With “co-operation” we get the economic and quasi-bio-economic Spencer. Again to quote Lloyd Morgan:—

It was amid phenomena which admitted of interpretation from the biological, or quasi-biological, point of view that he found his most congenial sphere of work and the one in which his method was most effectively employed. The story of evolution is the story of inter-related changes. In any organic whole there are certain salient features of the historical sequence. The parts get more different from each other, and they also get more effectively connected with each other; the individual whole gets more different from its environment, and it also preserves and extends its connexion with the environment; the several individuals get more different from others, while their connexion with others is retained and new connections are established. Nowadays these central ideas may seem familiar enough; but that is just because Spencer’s thought has been so completely assimilated.

The story of evolution is the story of inter-related changes! This, I hold, is due to the essentially symbiotic character of the activities of life.

When Spencer (rightly) says “manifestly that which is essential to Life must be that which is common to Life of all orders,” we are again in complete agreement with him. All things sharing with us the same biological necessities, the same or kindred pleasures and vicissitudes, and inter-connected in so many ways in the web of life, are possessed of life, and therefore possessed (*inter alia*) of one and the same “feeling”—a feeling of relatedness and of solidarity.

As regards Herbert Spencer’s final definition which he thinks the broadest and most complete, viz., “The continuous adjustment of internal relations to external relations,” we must reject it as inadequate, especially as regards psychological factors. This definition exaggerates the passivity of life, and, according to his own warning, so abstract a formula is scarcely fitted for biological purposes.

E.—THE DEGREE OF LIFE VARIES AS THE DEGREE OF
CORRESPONDENCE.

His universal process of Evolution is supposed to have given Spencer a criterion of “higher” and “lower” “progression” and “degeneration” independent of the accidents of actual history, and “unattainable by strictly Darwinian methods” (*Encyclopædia Britannica*).

“The higher (at least in times of evolution) is the more complex and differentiated whether it invariably survives or not” (*Ibidem*).

It is Spencer’s merit to have provided a criterion of “higher” and “lower” at all, though, as we shall see, it is an unsatisfactory one, when Darwin’s teaching apparently did not justify any such deductions. Yet, as we have already seen, it needed only an extension and a proper interpretation of the invaluable spade-work done by Darwin as regards the importance of biological inter-action, to arrive at a valid standard of biological usefulness, congruous with the most rational human methods of computation of values and of sifting the grain from the chaff, *i.e.*, the physiological from the pathological.

Spencer tells us that, “In life of the lowest order, we find that only the most prevalent co-existences and sequences in the environment, have any simultaneous and successive changes answering to them in the organism.”

This is very true, but in addition it must always be recognised that normally even with primitive life it is the bio-economic contingencies that count most.

How signally the great synthetic philosopher here fails to do justice to the bio-economic view at once becomes apparent when he continues: “A plant’s vital processes display adjustment solely to the continuous co-existence of certain elements and forces surrounding its roots and leaves; and vary only with the variations produced in these elements and forces by the sun—are unaffected by the countless mechanical and other

changes occurring around; save when accidentally arrested by these."

One might think on reading these lines that a plant is not concerned at all in biological symbiosis.

"Progress towards more prolonged and higher life evidently implies an ability to respond to less general co-existence and sequences."

What is this progress if not one in increased bio-economic specialisation and usefulness? Responding to "less general co-existences and sequences" may mean anything; in particular, as we have seen, it may and must frequently mean pathogenesis, *i.e.*, degeneration, retrogression—falsely called "simplification," and such a consummation cannot produce "progress towards a more prolonged and higher life."

"Each step upwards must consist in adding to the previously-adjusted relations which the organism exhibits, some further relation parallel to a further relation in the environment."

How is such an increase of (sympathetic) relatedness to be achieved? The fact that the position of a plant in the scale of evolution is in accordance with its productiveness of biological values is proof that there are definite bio-economic, *i.e.*, symbiotic methods of achieving progressive relatedness, and that purely mechanical adjustments can at best be but subordinate.

"Other things equal," Spencer thinks that greater correspondence must show itself in greater complexity of life, and greater length of life, which is again quite plausible so long as the proviso is read to contain the bio-economic implications that we have emphasised.

Spencer, of course, perceives that there is a lack of uniformity on his view of progress. But he consoles himself. "It needs but to compare a microscopic fungus with an oak, an animalcule with a shark, a mouse with a man, to recognise the fact that this increasing correspondence of its changes with those of the environment, which characterises progressing life,

habitually shows itself at the same time in continuity and in complication."

Such a sweeping view is roughly correct and congruous with the belief that evolution is a great fact, although it is not backed up by a satisfactory account of the inter-relations between organism and environment.

As has been said before, gratitude is due to both Spencer and Darwin for having made their great and sweeping statements, although, in so far as they could not fully establish them in their day, the statements had to remain somewhat premature. Prof. Bateson, as we have previously seen, so far as Darwin is concerned, in speaking of the difficulties presented by heredity, specifically acknowledges this, and even Samuel Butler, the greatest of Darwin's opponents, acknowledged Darwin's merit: "He found the world believing in fixity of species, and left it believing—in spite of his own doctrine—in descent with modification."

"*Palmarum qui meruit ferat.*"

Similarly the reading of Spencer's works must have inclined many to believe in progress and in the inevitability of progress in spite of the inadequacy of some of his explanatory methods. Spencer, indeed, and as we have previously seen, goes so far as to recognise that, generally speaking, "as the life becomes higher, the environment itself becomes more complex." He thinks that a zoophyte rooted to a stone need undergo no internal changes such as those by which the caterpillar meets the varying effects of gravitation while creeping over and under the leaves. This is the old "post hoc ergo propter hoc" fallacy in which Darwin also was fond of indulging, as if organisms were not also themselves responsible, as it were, for their environment and their biological conduct had no place in the improvement of the environment.

A sessile animal, however, is usually a degenerate animal, being commonly thereby divorced from the possibility of symbiosis, and the changes it undergoes are consequently of the

pathological order, and are not calculated to make for the attainment of a higher plane of existence, *i.e.*, for progress.

As soon as he begins to trace "upwards from the amphibia" the widening extent and complexity of the web of life, Spencer obviously inclines towards a bio-economic criterion of status. He observes "how increasing heterogeneity in the flora and fauna of the globe, itself *progressively complicates* the environment of each species of organism." (Italics mine.) Nay, he thinks—and there he clearly again adumbrates the view that Bio-Economics and Political Economy are closely related—that "it might finally be shown that the same general truth is displayed in the history of mankind," who have constantly improved their physical and social environment and advanced their civilisation by symbiotic activities and division of labour.

F.—GROWTH.

In Chapter II. I have already dealt with some of Spencer's conclusions as regards Growth. How completely he missed the Bio-Economics involved in nutrition may be gauged from the following passage:—

Around a plant there exist certain elements that are like the elements which form its substance; and its increase of size is effected by continually integrating these surrounding like elements with itself. Nor does the animal fundamentally differ in this respect from the plant or the crystal. Its food is a portion of the environing matter, that contains some compound atoms like some of the compound atoms constituting its tissues; and either through simple inhibition or through digestion, the animal eventually integrates with itself units like those of which it is built up, and leaves behind the unlike units.

As regards the *ultimate* constituents or elements required as food, this is true, but we need to look a good deal further and then we see that the combinations of the required elements available require work on the part of the organism before the essential elements are ready for use. Thus, for instance, the significance of photosynthesis is entirely omitted. The green plant has the power of building up living substance from inorganic material, but the animal cannot, and there is

therefore a vital difference between plant and animal, and their mutual relations involving work had to be shaped, as we have seen, in accordance with symbiotic reciprocities. Neither can grow by *merely* ingesting "like elements with itself." In order to grow they must first earn their living by work.

So far from depending on "like elements with themselves," it may be said that they really depend on that which is *unlike* themselves, though bio-economically and physiologically adequate, *i.e.*, on cross-feeding. That plant and animal in following their normal nutritive instincts can be seen actively to transmute or integrate material coming from lower kingdoms into nobler biological currency (nutritional "amphimixis") is indeed the most important fact to be noted in connection with growth. Their similarity consists principally in the fact of a mutual bio-economic purpose underlying their respective specialisation, although the plant here shows itself superior in creative power. Otherwise plant and animal require unlike material for unlike (though reciprocal) purposes. In his chapter on "Development," Spencer indeed contradicts his assertion that an organism requires for its food elements like itself. "And when we pass to the superior classes of organisms—land-plants and land-animals—we find that, chemically considered, they have little in common either with the earth on which they stand or the air which surrounds them." "Thus, on contemplating the various grades of organisms in their ascending order, we find them more and more distinguished from their inanimate media, in *structure*, in *form*, in *chemical composition*, in *specific gravity*, in *temperature*, in *self-mobility*." (Italics mine.)

He almost may be said there to go so far as to put the case of genuine adaptation *v.* "extreme determination," *i.e.*, of physiology *v.* pathology. "We may say that in proportion as an organism is physically like its environment, does it remain a passive partaker of the changes, as it is endowed with power of counteracting such changes, it exhibits greater unlikeness to its environment."

He also concedes, very fairly, in the same chapter, "that some kinship seems to exist between these generalisations and the doctrine of Schelling, that Life is the tendency to individuation."

Spencer thinks, as we have already noticed, he may with safety say that "other things equal" (always a cautious proviso to make!) "the growth of an animal depends on the abundance and sizes of the masses of nutriment which its powers enable it to appropriate." But here he feels the need of another proviso:—

Perhaps it may be needful to add that, in interpreting this statement, the number of competitors must be taken into account. Clearly, not the absolute, but the relative abundance of fit food is the point; and this relative abundance very much depends on how many individuals are competing for the food.

That the production and the abundance of "fit" food are primarily matters of biological co-operation is entirely overlooked, and with such crude views, Spencer, of course, is totally at a loss to draw a distinction between wholesome and unwholesome food, as also between wholesome and unwholesome competition. If his *Principles of Biology* are thus inadequate in the light of the profounder study of to-day, his views—drawn as they are from a wide experience of life—are at least generally suggestive and remain broadly true, while they did immense service in giving a survey of the whole field and focussing attention on fundamental principles. It is also fair to point out that Spencer was not entirely oblivious of the fact that certain proportions are required in food. Thus he states: "The total absence of lime from its food may stop the formation of a mammal's skeleton; thus dwarfing, if not eventually destroying, the mammal; and this, no matter what quantities of other needful colloids and crystalloids are furnished."

He is thus clearly pointing to a "deficiency disease," although to what a startling extent the absence of subtle but vital substances elaborated by the plant may be the cause of such "deficiency diseases" was, of course, not realised in Spencer's day.

G.—FUNCTION.

In this chapter Spencer recognises that the leaves and sap vessels in a tree, and those organs which in an animal similarly carry on nutrition and circulation, as well as those which in the animal generate and direct muscular motion, must be considered as *dynamical* in their actions, and he speaks of the “accumulation of force” as latent in food and the “transfer of force” as latent in the prepared nutriment or blood.

These dynamic conceptions are similar to those for which I have so far pleaded. As soon as the bio-economic importance of nutrition is realised, the further step to more accurate bio-dynamic conceptions follows naturally and necessarily.

He also tells us that physiology, in its concrete inter-relations, recognises special functions as the ends of special organs: the teeth as having the office of mastication; the heart as an apparatus to propel blood; this gland as fitted to produce one requisite secretion, and that to produce another; each muscle as the agent of a particular motion; each nerve as the vehicle of a special sensation or a special motor impulse. It follows that the study of the economic, *i.e.*, co-operative interactions and inter-relations of organs and organisms should be certainly within the province of physiology, and indeed one of its most vital objects.

“Physiological division of labour,” according to Spencer, is a very apt term (coined by Milne-Edwards and adopted with full approval by Darwin).

Perhaps no metaphor can more truly express the nature of this advance from vital activity in its lowest forms to vital activity in its highest forms. And probably the general reader cannot in any other way obtain so clear a conception of functional development in organisms as he can by tracing out functional development in societies; noting how there first comes a distinction between the governing class and the governed class; how while in the governing class there slowly grow up such differences of duty as the civil, military and ecclesiastical, there arise in the governed class, fundamentally industrial differences like those between agriculturists and artisans; and how there is a continual multiplication of such specialised occupations, and specialized shares of each occupation.

Precisely. Physiology, as well as Bio-Economics, are truly analogous to Political Economy. Both Darwin and Spencer saw the great importance of division of labour, but did not go the whole length of the economic argument, which I am here enforcing and which I believe to be so essentially and universally true, and indispensable in considering all biological problems.

Spencer is also struck by the increasing dependence of life on co-operation.

From instant to instant, the aeration of blood implies that certain respiratory muscles are being made to contract by certain nerves; and that the heart is duly propelling the blood to be aerated. From instant to instant digestion proceeds only on condition that there is a supply of aerated blood, and a due current of nervous energy through the digestive organs. That the heart may act, it must from instant to instant be excited by discharges from certain ganglia; and the discharges from these ganglia are made possible only by the conveyance to them, from instant to instant, of the blood which the heart propels. It is not easy to find an adequate expression for this double re-distribution of functions.

I have already introduced the term reciprocal (or symbiotic) differentiation as applicable to the combined physiological and bio-economic activities involved, which can be seen to be strictly analogous to well-understood functions in human society, which Spencer perceives, and asks us to observe how the increasing division of labour in societies is accompanied by a closer co-operation.

While local divisions and classes of the community have been growing unlike in their several occupations, the carrying on of their several occupations has been growing dependent on the due activity of that vast organisation by which sustenance is collected and diffused.

If citizens (or organisms) are thus "growing unlike" to satisfy the demands of the increasingly complex web of life, their increasing mutual dependence constitutes a very important element making for likeness in many ways, and should certainly and normally prevent extreme degrees of antagonism (hostility) in spite of unlikeness.

The physiological division of labour is usually not carried

so far as wholly to destroy the primary physiological community of labour.

Neither could it very well be carried so far except in abnormal (parasitic) cases, where self-gratification rather than bio-economic contribution is becoming the order of the day and permanence is sacrificed.

As in societies the adaptation of special classes to special duties does not entirely disable these classes from performing each others' duties on an emergency; so in organisms, tissues and structures that have become fitted to the particular offices they have ordinarily to discharge, often remain partially able to discharge other offices. It has been pointed out by Dr. Carpenter, Spencer tells us, that "in cases where the different functions are highly specialised, the general structure retains, more or less, the primitive community of function which originally characterised it."

The prevention of over-specialisation, as we have already seen, should be the aim of all organisation, of all genuine adaptation. It is as important as the prevention of disease. An organism can remain fully alive to the contingencies of existence only if it maintains a sufficiency of fruitful symbiotic correspondences.

Those parts of plants which show so considerable a power of discharging each others' offices, are not widely unlike in their minute structures. And the tissues that in animals are to some extent mutually vicarious, are tissues in which the original cellular composition is still conspicuous. But we do not find evidence that the muscular, nervous, or osseous tissues are able in any degree to perform those processes which the less differentiated tissues perform. Nor have we any proof that nerve can partially fulfil the duty of muscle, or muscle that of nerve. We must say, therefore, that the ability to resume the primordial community of function, varies inversely as the established specialization of function; and that it disappears when the specialization becomes great.

There is, of course, no need in a "high" organism to resume the primordial community of function for ordinary purposes, for the simple reason that it is now adapted to bio-economic purposes of quite a different degree from that pre-

vailing at the origin of its species, and that also it has firmly established a number of biological correspondences on which it can rely as a human being can rely upon tools. Reliance on the web of life, and corresponding adaptation, is up to a certain point quite legitimate. So long as the specialisation permits the continuance of bio-economic usefulness on sufficiently broad lines to prevent the arrival at a blind alley, physiological division may depute a great deal of activity to automatic function, *i.e.*, to fixed organs. What is thus demanded of every organism and of every species in order to achieve survival is, as we have seen, a certain loyalty to the great cosmic, *i.e.*, symbiotic principles of life generally. Though the specialisation is great in the highest organisms, and though frequently they quite legitimately rely upon a number of symbiotic external fixtures, yet, as we have seen, they require to be passed through the unicellular state, and this for the very reason of preserving them duly symbiotic, *i.e.*, for symbiogenetic purposes, which are the opposite ones of selfish "over-specialisation" and of disease.

We may here also in passing note that Spencer ventures the opinion that "function is from beginning to end the determining cause of structure."

H.—WASTE AND REPAIR.

The deductive interpretation of the phenomena of Repair, according to Spencer, is by no means easy. "The tendency displayed by an animal organism, as well as by each of its organs, to return to a state of integrity by the assimilation of new matter, when it has undergone the waste consequent on activity, is a tendency which is not manifestly deducible from first principles, though it appears to be in harmony with them."

Then there is "the relative assimilation" by which the repair of organs is effected that wants accounting for, seeing that organs are in part made up of units that do not exist as such in the circulating fluids.

Spencer here again concedes that "groups of compound units have a certain power of moulding adjacent fit materials into units of their own form," *i.e.*, that they have a certain creative or individualising power, *i.e.*, they possess incipient personality. These groups of compound units, "capable of resuming their structural integrity after they have been wasted by function," indeed suggest the analogy of human personality. We have previously seen that similar considerations caused Spencer to incline to Schelling's definition of Life as "the tendency to individuation," and his renewed difficulties in trying to square these individual "powers" of units with his mechanical *First Principles* rather emphasises again the superiority of Schelling's definition of Life to his own.

As regards that other kind of repair which shows itself in the regeneration of lost members, Spencer thinks that we have no alternative but to conclude that the aggregate forces of the body control the formative processes going on in each part, which, I would note, again seems to point to some kind of central or regulating principle of individuality in the organism.

Recent pathological study appears to lead in the same direction. Thus Dr. Bashford says, in reference to cancer, that "the physiological balance, with self-regulation perfect on normal days, is thrown out of adjustment." (Recovery, *i.e.*, restoration or "regeneration" of lost integrity, in this case, is rare.)

Spencer's hypothesis that a plant or animal of any species is made up of special units, in all of which there dwells the intrinsic aptitude to aggregate into the form of that species, is based on the famous and much-quoted example of a fragment of a Begonia leaf imbedded in fit soil developing into a young Begonia.

But, as Mr. H. C. Davidson has shown, this "asexual" reproduction really depends on the presence of buds, *i.e.*, plantagens, *i.e.*, specially differentiated and individualised entities (members of a symbiotic union); and the significance

of such operations as budding, grafting, and striking cuttings is quite different from that phenomenon whereby, say, a crustacean can sometimes replace a missing limb. The latter kind of regeneration, as Mr. Davidson points out, "does not create a new individual, it merely provides a substitute—generally, if not invariably a poor one—for some comparatively unimportant part which an existing individual has lost."

Such regeneration seems to be only an effort of those entities called the somatic cells, which in some instances (owing to the particular contingencies of the life of the species) have retained some of the powers of reproduction, which in other cases, showing greater symbiotic—and, therefore, more reliant—specialisation, have become totally deputed to the sexual cells.

Of the frequent regeneration of a plant from a bit of a leaf, Spencer says: "It seems difficult to conceive that this can be so; but we see that it *is* so." Being mistaken about the true inwardness of the phenomenon, he makes the following remarks:—

Manifestly, too, if we are thus to interpret the reproduction of an organism from one of its amorphous fragments, we must thus interpret the reproduction of any minor portion of an organism by the remainder. In the one case as in the other, the vitalized molecules composing the tissues show their proclivity towards a particular arrangement; and whether such proclivity is exhibited in reproducing the entire form, or in completing it when rendered imperfect, matters not. For this property there is no fit term. If we accept the word polarity as a name for the force by which inorganic units are aggregated into a form peculiar to them, we may apply this word to the analogous force displayed by organic units. But, as above admitted, polarity, as ascribed to atoms, is but a name for something of which we are ignorant—a name for a hypothetical property which as much needs explanation as that which it is used to explain.

I have already defined polarity as bio-dynamic character, a definition which meets the case of "regeneration and integrity" because of the implied incipient individuality.

According to Spencer this specific polarity cannot dwell in those proximate chemical components composing organic bodies; not in the atoms of albumen, or fibrine, or gelatine.

How else could we account for the unlikenesses of different organisms, all of which are composed of these atoms? If the polarities of the chemical atoms determined organic form, how could we account for the occurrence of such endlessly varied forms as nature presents? Hence Spencer postulates his "physiological" units as the ultimate agents of form. We have seen from the case of plantagens that the power of reproduction of organic form depends in reality on the presence of individuality, and we must suspect that it is a similar kind of individualised unit which is at the base of form. Such units we have already seen to change according to bio-economic specialisation, *i.e.*, they are responsive and responsible, though primitive, members of the biological world.

The question of individuality is broached in Spencer's special chapter on that subject, when the conclusion is reached that no definition of individuality is unobjectionable, and that "we must be content with a course which commits us to the smallest number of incongruities."

Something seems to be gained by restricting the application of the title individual to organisms which, being in all respects fully developed, possess the power of producing their kind after the ordinary sexual method; and denying this title to those incomplete organisms which have not this power. But the definition does not really establish this distinction for us. On the one hand, we have cases in which, as in the working bee, the whole of the germ-product is aggregated into a single organism; and yet, though an individual according to the definition, this organism has no power of reproducing its kind. On the other hand, we have cases like that of the perfect *Aphides*, where the organism is but an infinitesimal part of the germ-product; and yet has that completeness required for sexual reproduction. Moreover, if we adopt the proposed view, we find ourselves committed to the anomalous position, that among many orders of animals there are no concrete individuals at all. If the individual is constituted by the whole germ-product, whether continuously or discontinuously developed, then, not only must individuality be denied to each of the imperfect *Aphides*, but also to each of the perfect males and females; since no one of them is more than a minute fraction of the total germ-product. And yet further, it might be urged, with some show of reason, that if the conception of individuality involves the conception of completeness, then, an organism which possesses an independent power of reproducing itself, being more

complete than an organism in which this power is dependent on the aid of another organism, is more individual.

In pursuance of his conception of life, however (which, as we remember, tacitly implies an "inner nature"), Spencer finally inclines to the view as regards individuality that "we must record the title to each separate aphid, each polype of a polypedom, each bud or shoot of a flowering plant, whether it detaches itself as a bulbil or remains attached as a branch."

If the bud be thus considered as a biological individual, and if, as we have seen, without the presence of a bud reproduction will not proceed, we can see again how greatly reproduction depends on individuality, and how not only reproduction but, in fact, all biological production must depend on individuality, *i.e.*, on personality and character, however incipient.

I.—ADAPTATION.

As this subject and a great part of Spencer's chapter thereon have already been treated, it remains to say something about a modern view concerning adaptation.

The well-known view of the Rev. Prof. G. Henslow is that of "Self-Adaptation to Changed Conditions of Life," *i.e.*, that the adaptations of plants, for instance, are not, as Darwin's theory might lead one to suppose, a mere matter of "accident," but that the structural peculiarities of plants can often be proved by induction and experiments to be the inciting causes to which the plant responds, and builds up the very tissues which are requisite for the occasion.

In other words, this means that plants in making their adaptations behave much as human beings would, *i.e.*, that they show individuality, a view to which, of course, we offer no objection. Prof. Henslow opines that Nature herself is frequently making experiments, which seems a round-about and paradoxical way of expressing what is really to be conveyed, *viz.*, that organisms must remain adaptive to changes of season and of circumstances, much in the same way as this is required of man in his changing circumstances. I fail to see any gain of clearness in the repeated attempt to impute to

Nature a proclivity for experiment-making. Is it not enough that Nature produces soil, seasons and opportunities for progressive adaptations?

Says Prof. Henslow:—

Thus, if a pond dries up, what will become of the submerged water crowfoot? Will it perish in the changed conditions of air instead of water? Not at all! The seeds germinate in the mud, develop the dissected type of leaf characteristic of many submerged plants, but the new plant alters the anatomical structure in order to suit it for an aerial existence, and flourishes even more vigorously than when it was submerged!

This is a perfectly good example of self-adaptation; and, what is more, this plant belonging to the genus *Ranunculus*, like the frog (*rana*) from which the name of the genus is derived, the plants being common in the places where frogs abound, is able to make a progressive adaptation from aquatic to terrestrial conditions.

This is, however, more than many other plants and animals can afford to do, for whether organisms can adapt themselves progressively or not depends on their habits, and adaptation really begins with habits rather than with obvious changes of structure, *i.e.*, with physiological rather than morphological change. The power of adaptation depends on the powers of response and on the kind of biological correspondences established by symbiotic activities. True, seasons are helpful, but only really so to those who remain strenuous, *i.e.*, only with right use; whilst those who abuse seasonal gifts, like the parasites, become highly fastidious and unable to form wholesome or enduring adaptations for lack of correspondences, and also because of atrophy of vital parts.

Prof. Henslow, however, does not make these vital distinctions, and his view, though otherwise to be welcomed as an advanced view, still remains inadequate; lacking, as Prof. Marcus Hartog would say, in “symmetrical completeness.”

The proofs that plants of special “associations” have acquired their adaptive structures by a direct response to the new conditions of life

rest on *Induction* and *Experiment*. By the former is meant the fact that many plants of widely different families assume the same special forms under similar conditions of life; and the just inference is that there is a distinct cause and effect, so that they bear "mimetic" characters. Such, *e.g.*, is well seen in the fleshy, massive stems of Euphorbias, Stapelias, etc., of Africa, which resemble members of the Cactus family of Mexico; and the true Aloë of Africa is just like the "American Aloe" or Agave of Mexico.

Photosynthetic plants are, in a sense, always "mimetic" in that they all alike contribute in a definite manner to one great cause, *viz.*, synthetic evolution, *i.e.*, symbiogenesis. The outwardly appearing wholesome diversification in plants is only, as we have seen, in keeping with the differing degrees to which they have managed to perfect their productive powers *pari passu* with their morphological complexity.

The most vital adaptation of plants, the main theme from which all others are but variations, is thus beyond any need of being established by laboratory experiments. Indeed, we may say that all such experiments which fail to take the fundamental bio-economic adaptations of the plant fully into account must be fallacious, or can at best only yield very partial results.

Seeing that fundamentally the great bio-economic duty of plants makes for one great fundamental symbiotic adaptation (for work), it is not difficult to understand that with the arrival of similar external conditions cases of "convergence" may easily arise; *i.e.*, that plants may make additional adaptations to similar external conditions in similar ways, although there may be no affinities or any relations between them whatever. The very fact that one and the same (symbiogenetic) theme underlies all genuine specialisation and gives the direction to evolution must easily cause the variations from this theme to approach one another as soon as for all of them identically changed conditions arise.

It is only those organisms that lived to no positive bio-economic purpose, like the parasites, that can afford,

though retrogressively and for a time, to change almost indifferently and indefinitely. If Prof. Henslow, who speaks of depauperised plants (some species of different genera have been actually named *depauperata*, the degraded characters having become fixed and hereditary), were more thoroughly consistent, he would speak of self-pauperisation as the antithesis of progressive self-adaptation ("self-made" plants), instead of which he pleads that the causes of degeneracy reside in the external agencies (although otherwise fully admitting that parasitism is also a factor of degeneracy). Apparently he is influenced by the fact that degenerations in plants are so numerous as to appear almost normal. Such errors are clearly due to the non-appreciation of the bio-economic factors. Production, in spite of all degeneration, remains predominant, and, what is more, measured by degrees of productiveness, it is possible to make the vital distinction between progressive "degeneration," *i.e.*, atrophy of the biologically useless, and retrogressive degeneration, *i.e.*, atrophy of the biologically useful. How sadly such standardisation is wanted is thus again evidenced by Prof. Henslow's writings.

K.—VARIATION.

Under this heading, Spencer notes that the transmission of variations is itself variable, and that it varies both in the direction of decrease and in the direction of increase.

An individual trait of one parent may be so counteracted by the influence of the other parent that it may not appear in the offspring; or not being so counteracted the offspring may possess it, perhaps in an equal degree, or perhaps in a less degree; or the offspring may exhibit the trait in even a still higher degree.

We thus get an illustration of the possibilities of amphimixis and of the play of opposites—determined in the long run as to its results, by values, as we have seen in the chapter on Genetics. In illustration of this proposition, Spencer cites the case of the transmission of six-fingeredness in certain families, and although he fails to draw the line between

physiological and pathological development and to read all biological antagonism in the light of values as one might have wished him to do, yet his *quasi* bio-dynamic views again disclose his great grasp of biological principles. The unlikeness among progenitors to him is only one antecedent of variation, but by no means the sole antecedent.

Were it so, the young ones successively born to the same parents would be alike. If any peculiarity in a new organism were a direct resultant of the structural differences between the two organisms which produced it, then all subsequent new organisms produced by these two would show the same peculiarity. But we know that the successive offspring have different peculiarities; no two of them are ever exactly alike.

One cause of such structural variation in progeny is functional variation in parents. Proof of this is given by the fact that, among the progeny of the same parents there is more difference between those begotten under different constitutional states than between those begotten under the same constitutional state. It is notorious that twins are more nearly alike than children born in succession. The functional conditions of the parents being the same for twins, but not the same for their brothers and sisters (all other antecedents being constant); we have no choice but to admit that variations in the functional conditions of the parents are the antecedents of those greater unlikenesses which their brothers and sisters exhibit.

Variations in the functional conditions of the parents are indeed answerable for much unlikeness of progeny. This is strikingly manifested when the variations in bio-economic functions in the long life of species are duly accounted for. The majority of variational and specific unlikenesses will then be seen to be but variations from one great biological, viz., a symbiogenetic, theme. The testimony from all sides in favour of this view is so overwhelming that, in spite of the apparent fixity of "characters" and their frequent segregations according to Mendelian ratios, we have no choice but to admit that in the last analysis in Nature it is bio-economic factors that are responsible for the arrival and fate of noteworthy variations—a recognition which, I believe, has not its equal in importance in the whole field of Biology.

Spencer also thinks that a definite cause must be assignable for apparently spontaneous variations.

In any series of dependent changes a small initial difference often works a marked difference in the results. The mode in which a particular breaker bursts on the beach may determine whether the seed of some foreign plant which it bears is or is not stranded—may cause the presence or absence of this plant from the flora of the land; and may so affect for millions of years, in countless ways, the living creatures throughout the land.

Whilst this is quite true, yet it remained to discover the definite and persistent principle, capable, as Samuel Butler would say, of acting as a rudder and compass to the accumulation of variations, and of making it keep steadily on one course for every species, until eventually many havens far remote from one another are safely reached.

The reproductive centres must begin to differentiate from the very outset, says Spencer, “since the *process of nutrition* cannot be absolutely alike for all.” (*Italics mine.*)

What has escaped him here is that if the unlikenesses and fluctuations following in the wake of metabolic fluctuations have not generally assumed undue proportions, this is entirely due to those beneficent dual amphimixis and concomitant safeguarding effects resulting from proper feeding on which I have all along insisted. There are also, according to Spencer, qualitative differences—different kinds of influences—affecting the germ-cells or sperm-cells. “Amid countless different combinations of units derived from parents, and through them from ancestors, immediate and remote—amid the various conflicts in their slightly different polarities, opposing and conspiring with each other in all ways and degrees; there will from time to time arise special proportions causing special deviations.” And he cites a very valid objection to his own “chance” view. It is this: “As the members of a species whose circumstances have been altered will be affected in the same manner, the results, when they begin to show themselves in descendants, will show themselves in the same

manner; not multiform variations will arise, but deviations all in one direction."

Although he calls this "a simple reply," yet it is really too indefinite to meet the argument. He has overlooked the great and powerful influences working inconspicuously through time, viz., the bio-economic or symbiogenetic influences which are the perennial determinants of variation. Hence he is obliged constantly to refer to "chance," or to dwell only on secondary and local changes.

That those various local influences which he enumerates all have their effects is, of course, undeniable, but to what an extent they are indeed neutralised and outclassed by the perennial symbiogenetic influences is quite a different matter, and one which he hardly helps us to determine.

Just as men of slightly-unlike dispositions behave in quite opposite ways under the same circumstances, or just as men of slightly-unlike constitutions get diverse disorders from the same cause, and are diversely acted on by the same medicine; so the insensibly-differentiated members of a species whose conditions have been changed may at once begin to undergo various kinds of functional changes.

All of which contains much that is true, though not unqualifiedly true, and of secondary importance. The bond of symbiogenesis, in spite of all organismal vagaries, as we have seen, unites all strenuous organisms and tends to keep them on the straight path, and frequently in spite of themselves, as one might say. The arrival of physical disorders is not a matter of mere chance, but a matter of transgression of biological laws which cannot be tolerated long without leading to pathogenesis. If a morbid tendency has been permitted to get a firm footing, elimination in one shape or form has to set in, and whilst one class of pathogenetic organisms is thus being eliminated, the wholesome symbiogenetic union of strenuous organisms is going forward all the time. Initial contrasts there may be in abundance, but, as we have seen, they cannot all continue indefinitely, and an increasing biological

antagonism (according to values) makes an end of every biological iniquity. The "multiform beast" (an expression used long since by Plato to characterise one who in Scriptural phrase "enlarges his desire as hell") constantly loses in survival capacity, and still variation remains in a definite direction. It is quite true that an initial false step, if persisted in, may prove the final undoing of a species, but the establishment of new habits cannot be a mere matter of accident, seeing that all organisms persist in virtue of those definite bio-economic specialisations which they have embraced. Upon any change of environment, the old habits and conditions will largely determine the choice of new. Apart from this, by calling for renewed (symbiotic) efforts a change of environment in the majority of cases will in itself act as a means of bio-economic regularisation, just as inter-crossing, according to Darwin, "plays a very important part in Nature in keeping the individuals of the same species, or of the variety, true and uniform in character" (*i.e.*, in Spencerian parlance, "the idiosyncratic divergences obliterate each other").

I am quite at one with Spencer in believing that functional divergences once established and having lasted long enough must have profound effects, but I do not overlook, as he does, the fact that normally a threefold line of defence against any extreme or sudden divergences, *viz.*, digestion, fertilisation, symbiogenetic momentum, has to be broken down before a retrogressive modification can be established, and that thus, in reality, the most powerful factors there are, normally make for definite and uniform progress of variations.

And thus the importance of function, as determining variation, is seen in an entirely new light, and we are justified in speaking of such biological development in terms of values (which are due to function) where previously we spoke in terms of accident or of mere Newtonian mechanics.

Spencer admits in a following chapter that: "Besides owing to the external world those energies which, from moment to moment, keep up the lives of its individual

members, every species owes to certain more indirect actions of the external world those energies which enable it to perpetuate itself in successive generations."

But he does not realise the extent to which the fact that every organism is thus evolved in correlation with the world ("mit der Welt verwachsen," as Fechner says), constitutes an additional perpetual and powerful directive influence in accordance with the degree and value of this correlatedness. He says: "When we remember that the force which keeps the Earth in its orbit is the gravitation of each particle in the Earth towards every one of the group of particles existing 91,000,000 of miles off, we cannot reasonably doubt that each unit in an organism acts, by its polar forces, on all the other units, and is reacted on by them."

What he omits is the consideration of the fact that the force of organic solidarity acts in a somewhat similar way in its effects upon organisms, and that this largely accounts for the "tolerably uniform conditions maintained by a species in spite of the phenomena of variations." If we supply the bio-economic addenda, how true it is also as he remarks in the "Preliminary" to his outline on *The Evolution of Life*, that "there is an *ensemble* of vital phenomena presented by each organism in the course of its growth, development, and decay; and there is an *ensemble* of vital phenomena presented by the organic world as a whole. Neither of these can be properly dealt with apart from the other." "What interpretation we put on the facts of structure and function in each living body depends entirely on our conception of the mode in which living bodies in general have originated."

L.—DISTRIBUTION.

Here Spencer touches upon the problem of distribution in Time, and raises the important questions of fitness, of creative skill, and of extinction.

There arise the questions—why during nearly the whole of that vast period geologically recorded, have there existed none of those

highest organic forms which have now overrun the earth. How is it that we find no traces of a creature endowed with large capacities for knowledge and happiness? The answer that the earth was not, in remote times, a fit habitation for such a creature, besides being unwarranted by the evidence, suggests the equally awkward question—why during untold millions of years did the earth remain fit only for inferior creatures? What, again, is the meaning of this extinction of types? To conclude that the saurian type was replaced by other types at the beginning of the tertiary period, because this type was not adapted to the conditions which then arose, is to conclude that this type could not be modified into fitness for the conditions: and this conclusion is quite at variance with the hypothesis that creative skill is shown in the multiform adaptations of one type to many ends.

The answer to these great and hitherto puzzling questions, to put it briefly, is that:—

(a) Evolution is constituted mainly by a gradual symbiogenetic process which could not gain appreciably in momentum until the web of life had become fairly complex; *i.e.*, until an adequate biological capital had been accumulated and the appropriate biological values, such as character and social dispositions, or, shortly, symbiotic condition, had arisen. In other words, a biological species or group cannot make progress any more than a highly organised society can be evolved till there is an accumulated surplus of food, *i.e.*, capital, permitting leisure and higher and specialised occupations.

(b) That organisms have been left free (in a sense) to choose between good and evil, and that many, in spite of splendid opportunities to the contrary, have chosen retrogression by pathogenesis rather than progress by symbiogenesis; that is to say, by indulging in bad rather than in good adaptations, in bad rather than in good “variability,” *i.e.*, by failing in (bio-moral) loyalty to life.

(c) That “fitness” is in the long run entirely a matter of bio-economic (symbiogenetic) usefulness, and that creative skill (and, for that matter, creative evolution also) is nothing if it is not also symbiogenetic skill (symbiogenetic evolution), *i.e.*, that no amount of skill *per se* is of permanent avail unless

making for proper symbiotic relations by an adequate accumulation of sympathetic biological correspondences.

Spencer's own "interpretation" is in part contained in the following famous passage:—

Slowly but surely, evolution brings about an increasing amount of happiness, all evils being but incidental. By its essential nature, the process must everywhere produce greater fitness to the conditions of existence, be they what they may. Applying alike to the lowest and highest forms of organisation, there is in all cases a progressive adaptation, and a survival of the most adapted. If, in the uniform working out of the process, there are evolved organisms of low types, which prey on those of higher types, the evils inflicted form but a deduction from the average benefits. The universal and necessary tendency towards supremacy and multiplication of the best applying to the organic creation as a whole as well as to each species, is ever diminishing the damage done—tends ever to maintain those most superior organisms which, in one way or other, escape the invasions of the inferior, and so tends to produce a type less liable to the invasions of the inferior. Thus the evils accompanying evolution are ever being self-eliminated. Though there may arise the question, Why could they not have been avoided? there does not arise the question, Why were they deliberately inflicted? Whatever may be thought of them, it is clear that they do not imply gratuitous malevolence.

What is the essential nature of the evolutionary process if it is not symbiogenesis? This alone, and not a mere lethal process, such as that contemplated by the specially limited kind of Natural Selection which ignores all criteria but immediate survival, could produce a desirable and permanently successful kind of fitness, viz., symbiotic fitness, measurable by definite standards of physiological and economic value and not merely referable to any haphazard and temporary environmental conditions ("be they what they may"!).

To say that there is in all cases a progressive adaptation amounts, as we have seen, to an indiscriminate mixing up of varying orders of facts. The increasing momentum in the direction of pathogenesis manifested by parasites, for instance, is not a truly progressive adaptation, but is quite the opposite of the gradual gain of symbiogenetic momentum on the part of strenuous organisms, resulting in a permanent uplift in the

scale of life. Nor is the survival of the "most adapted" frequently more than a deception. It is often achieved (for a time) at the expense of physiological capital and with degradation of types, and the "most adapted" are not necessarily desirably or enduringly adapted.

My principle of biological values supplies a quasi-moral standard by which to judge of tendencies in organisms and their variations, such as Spencer seems to desiderate and even vaguely to proclaim. By its means retrogressive vicious variations of habit, leading to degradations of function and structure are clearly and constantly distinguished from truly progressive upward changes, and the puzzles of parasitism and of much morbidity are got rid of, while Evolution becomes comprehensible as being finally an uplifting and improving process with a strong bio-moral sanction behind it. "Les phénomènes économiques ne veulent pas être envisagés seulement sous l'aspect technique, mais sous l'aspect juridique," as Bouglé says quite truly.

The same writer, by clever analysis, shows that as regards "un criterium objectif du progrès des organismes" (and *a fortiori* of human societies) present-day Biology is quite unable to provide such "un mètre du progrès."

Mais aucune loi naturelle ne nous autorise à distribuer ainsi l'éloge ou le blâme; des *jugements de valeur entrent* ici en ligne de compte qu'aucune constatation biologique ne saurait confirmer ni infirmer. Au vrai la théorie organique ne nous apporte aucune lumière ni sur les conditions d'existence propres à nos sociétés, ni sur leur évolution caractéristique, *a fortiori* sur leurs fins particulières. (*Italics mine.*)

La morale naturaliste tombe sous le reproche de n'introduire, qu'au prix d'une inconséquence, la "qualité" qui lui est nécessaire pour hiérarchiser les êtres.

It reads almost as gospel to hear from Spencer that preying on one another constitutes a biological evil, for he has previously made but the slightest references that could be interpreted in this sense. Even so, he seems to refer only to

what are usually termed pathogenic organisms, which are found associated with diseased and aggravating conditions, without troubling, for instance, about the occasional preying of, say, plant on plant or mammal on mammal. The Bible is far more outspoken on this matter than is Spencer, and the writer of the book of Job in particular here shows an insight deeper than that of Spencer's by adumbrating the value of cross-feeding:—

There is a path which no bird of prey knoweth
And which the vulture's eye hath not seen;
The lion's whelps have not trodden it
Nor the fierce lion passed by it.

Again, the "supremacy and multiplication of the best" in Spencer's philosophy seems to require an expedient proviso, such as "be they what they may"! The parasites and depredators are not the best, nor are they supreme as he seems to admit. Yet parasites multiply most rapidly, and, as Spencer himself reminds us (p. 342): "Of the animal kingdom as a whole, more than half the species are parasites." Indeed, that the evils accompanying evolution are ever being self-eliminated seems to come in rather as an after-thought of Spencer's, seeing that he has failed adequately to draw any definite line between good and evil factors in the biological world, as he has also failed to show whence the main eliminative forces proceed. If we rationally allow for the frailty of life—its proclivity to follow the lines of least resistance, to let its activities flow into wrong channels—there is indeed not the slightest need to have recourse to a theory of "gratuitous malevolence."

"Sure of qualities demanding praise,
More go to ruin fortunes, than to raise."

Spencer in the above passage rather suddenly introduces "happiness"; but biological happiness must chiefly consist of days of happy productiveness, when symbiogenesis is allowed to proceed without serious obstacles, when there is an

abundance of mutually fruitful relations, when there is a proper appreciation of values; in short, when (biological) virtue rules all over the world.

Happiness, to me, also includes the possession of the "treasures of the heart," and these require "love-foods," a tolerable amount of security in their production, and a great amount of mutual forbearance, mutual service and mutual (that is systematic and symbiotic) activities. All of which is antithetic to depredation, to exploitation and parasitic life of every kind, as it is also antithetic to indiscriminate "digestive transformation," such as results from in-feeding.

Spencer's own tendency as regards biological status, it is evident, was towards such criteria of "higher" and "lower" as are supplied by my bio-economic theory. He was debarred from realising the full significance of these criteria partly because his views were too mechanical, and partly because the far-reaching significance of nutrition and of symbiosis was scarcely appreciated in his days.

The same must be said of Darwin, who almost deprecated any attempt to reach such criteria, although otherwise he must be claimed as a pioneer of Bio-Economics.

Nor have modern biologists been able to make any appreciable advance on this position. Thus Le Dantec declares: "Il faut se méfier du mot progrès"; and Prof. D. N. Paton (*Hibbert Journal*, Jan., 1915) states: "What a high level is we do not know." . . . "The process of evolution gives no support to the idea of its being an advance towards some abstract-perfection." •

The great stumbling block in every case is parasitism, *i.e.*, its proper valuation.

Yet when we find Prof. Paton declaring that it is possible that multicellular organisms arose by an aggregation of separate units in *mutual nutritional relationship* to another—somatic cells thus grouping themselves round the genetic cells, with further possibilities of modification in chemical changes—this is in more than one sense an approach to the symbiogenetic

view. It is precisely the fuller study of mutual nutritional relations, of reciprocal relations, and of use-relatedness generally, that provides, as we have seen, the valid point of view of advance and of status.

As regards the subject of interactions determining development, Prof. Paton contents himself with a mere passing reference to the "Struggle for Survival," which can now no longer be considered satisfactory.* "C'est en effet une application bien vague," as Bouglé has it, "que l'expression classique: les êtres *luttent pour l'existence*."

* A more advanced view is that of a writer on Evolution in Chambers's Encyclopedia who emphasises the nature and degree of relations to offspring as providing a key to the greater aspects of classification. "Thus our ethical difficulty at length disappears, since the greater steps of advance in the organic world compel us to interpret the general scheme of evolution as primarily a materialised ethical process underlying all appearances of 'a gladiator's show.'"

CHAPTER V.

PATHOGENESIS.

There can never be a great physician who is not at the same time a good Physiologist.—SIR ANDREW CLARK, M.D.

In every period of life the integrity of the digestive organs is the best of all securities against invasion of every form of disease.—DR. ROBERT DICK.

Hunter was certainly no specialist. He strove earnestly to get an insight into that principle of unity which is the great characteristic of human organisation; that principle stood before Hunter as a principle of self-preservation, in which he seems to have recognised the essential dependence of the different parts upon each other; that condition which we express when, as in common language, we call man an "individual."—SIR WILLIAM GULL'S HUNTERIAN ORATION.

Nature alarmed (after a course of luxurious living resulting in gout) now adopts a severe but a salutary measure. . . . Then the storm bursts. . . . Woe to the man who *rashly* interferes with, or *suddenly* checks this salutary process of Nature, whether by external or internal means!"—DR. JAMES JOHNSON.

Observing the evils resulting from undigested aliment we surely ought cautiously to guard against them by proportioning the quantity of our food to the digestive powers."—DR. JOHN ABERNETHY.

Exuberance of nutriment, as of many of the other goods of life, is frequently rather a curse than a boon to the body."—SIR HENRY HOLLAND.

Ut sit magna, tamen certe lenta via deorum est.—JUVENAL.

Sunt lacrymæ rerum.—VIRGIL.

We have now seen that the progress of the world is achieved by symbiogenesis, and that a dual, *i.e.*, domestic and biological symbiosis as well as a dual, *i.e.*, nutritional and sexual amphimixis are the requisites. We have found that the wholesomeness of all physiological function and of all the vital powers and possessions of a species depend on symbiosis,

so much so that disease may be said to be primarily constituted by a disturbance or distortion of symbiotic factors. Cessation of biological symbiosis we found to mark the beginning of pathological development.

We have come across so many instances where disease had to be viewed as the antithesis of symbiogenesis, that the old maxim, "*Pathologia Physiologiam illustrat*," gained an enhanced significance, and that the terms retrogression and degeneration which we have already used as the obverse of symbiogenesis became practically identical with "pathogenesis." (Life may indeed be regarded as the field on which the interplay of the constructional and progressive principle of symbiosis with that of destructive and retrogressive anti-biosis is carried on; and this is, I believe, an illuminating guide in all biological investigation and discussion.) Retrogression and degeneration may be said to refer to the more ultimate and obvious forms of biologically retrograde redistribution of organic matter, resulting from long continued pathological transmission; pathogenesis to the principle of debasing, by merely expedient abstractions or conversions of materials, symbiogenetically noble into pathological and biologically degraded developments.

We have also seen the enormous physiological and bio-economic importance of nutrition, and we have come across instances of an urgent need of a change of diet in nature, indicating that certain kinds of diet are not in the true interest of the (indulging) species, but rather to the contrary.

Perpetual in-feeding, involving the habitual ingestion of biologically inadequate or superfluous food-substances, we found to be "abhorred by Nature," heavy physiological and biological penalties being exacted for all such offences.

The *modus operandi* in this process we found to bear many striking parallels to that of retribution in human polity and showing that, as in the case of Gresham's law in the economic world, bad physiological currency gradually drives out good currency, thus leading to evils in various forms and tending to

lower the status of the organism (social or biological). Everywhere, indeed, the bio-economic, physiological, and biochemical factors were found to dovetail into one another.

A further parallel of this kind exists in the fact of biological and physiological antagonisms according to values, expressing itself both in nutritional and genetic (Mendelian) phenomena.

We saw that Mendelian inheritance involved the extrusion of impure strains, and that segregation in reality constitutes a third line of defence of racial purity; digestion and antecedent fertilisation processes having previously done their part to preserve the race from impeding foreign matter.

Adequate (symbiotic) "nutritional" amphimixis we saw to form the basis of desirable genetic transmutation, the particular share of the fertilisation process in symbiogenesis consisting in the provision of scope for further and enhanced symbiotic efforts, leading up to a symbiotic "élan," by dint of which the highest concentration of the bodily powers is effected and an uplift of the race is brought about.

We also concluded that the power of reaction against injurious forces is essentially a symbiotic power, that it necessitates a reliance upon the symbiotic, *i.e.*, the concentrated or combined power of the organism as a totality. That there is a limit of wholesome reaction to mutilations and similar stimulations was evidenced by the case of pruning, which also showed that the deep-seated prejudice, especially among gardeners, in favour of mutilations and "stimulants" must be fought against.

In the majority of cases the reactions produced by mutilations and stimulations prove costly, and the loss of vitality very generally far outweighs what is gained in other directions. When an "infection," nutritive or genetic, is caused, the body is faced by the task of re-organising itself accordingly, which requires vitality, effort, and time, with special digestion, incubation, and maturation processes. If pathological strains are introduced, an "alloy" has to be formed, and costly

extrusions have to be resorted to at the expense of vitality and of symbiogenesis.

All these considerations, I submit, are of the utmost importance in their application to a phenomenon taken from the sphere of acute disease, which is now in more than one sense "acute," and occupies the minds of many of the foremost biological and medical investigators, viz., that of anaphylaxis, or serum-disease.

One of the principal investigators of anaphylaxis is Prof. Ch. Richet, whose book on the subject has been translated into English by Dr. J. Murray Bligh.

The book, according to Dr. T. R. Bradshaw, is "a clear and able exposition of certain striking, often alarming, phenomena which, in the opinion of the author and of others who have worked on similar lines, may be expected to follow the introduction into the organism, at long intervals, of successive doses of albuminous substances such as are employed in some of the modern methods of treatment (by serum)."

Anaphylaxis, says Prof. Richet, is the opposite condition to protection (phylaxis), and he "coined the word in 1902 to describe the peculiar attribute which certain poisons possess of increasing instead of diminishing the sensitivity to their action."

Further in his second chapter he says:—

As a result of the injection of a toxic substance into several animals of the same species a variable and individual effect can always be demonstrated. Some are very resistant, others intensely sensitive.

Similarly in the case of ingestion of certain foods:—

It has long been known that some people after eating shell-fish, mussels, or strawberries are liable to erythema, urticaria, and indigestion, with nausea and syncope; all these are phenomena having characteristics strongly resembling those of anaphylaxis. In such people very small quantities of the ingested substance produce marked symptoms, while in the majority of people the results are those of normal food, and no symptoms are produced.

The fact of anaphylaxis by ingestion is definitely proven, i.e., the ingestion of certain foods (particularly certain

albuminous substances) produces poisonous effects upon many individuals. It has been found that individual susceptibilities to such forms of poisoning are everywhere different, which is hardly surprising when we consider what differences of constitution there are in different persons, how variously they are predisposed by racial and individual feeding and other habits to various kinds of diathesis.

The "abnormal individual supersensitivity of some animals may be compared with the intense sensitivity of certain human beings to sero-therapeutic injections."

There seems nothing abnormal in the fact that men and animals show a similarity of reaction to mutilations and to the introduction of antibiotics—for as such we must consider these sero-therapeutic injections—although varying in the degrees of reaction. The fact that the reaction is universal and attended by distinct and serious pathological symptoms, indeed, necessitates the inference that for some reason or other the injection of sera is biologically injurious, that there exists a biological antipathy against such methods of treatment as necessitate their use.

It has also turned out that children of tuberculous parents show increased susceptibility to infection by the tubercle microbe, which is "directly due to modification of disposition"—a predisposition which "may be associated with a kind of anaphylaxis," *i.e.*, the individuals of such a stock have become hereditarily "sensitised" by some poison to such an extent as to diminish the usual resistance of their race to the attacks of the tubercle bacillus. (Dr. C. E. Woodruff, late of the United States Army Medical Corps, is of opinion that both serums and vaccines tend to provoke tuberculosis, and to weaken resistance to diseases other than the one against which each is specific.)

The increased sensitiveness of tubercular stocks is due, in my view, to a loss of symbiotics calling for active intolerance of all new poisons. The same must be said of all those organisms which through in-feeding and other biological transgressions have suffered a loss of symbiotics, although it is customary to

overlook entirely the incipient, *i.e.*, the really sensitising stages of the in-feeding diathesis. We have seen that the ingestion of highly albuminous (animal) substances, if not biologically adequate, *i.e.*, not symbiogenetically derived, must lead to trouble.

We must likewise remember that frequently the partaking of a meal consisting largely of such albuminous food leads to (so-called dietetic) albuminuria, *i.e.*, presence of albumin in the urine, *i.e.*, the function of the kidneys and of the general metabolism is already markedly disturbed when these symptoms arise. The same must be said of arterio-sclerosis. Thus the *Lancet* (27/6/14), speaking of a book by Dr. F. L. Bishop on this subject, says:—

We have long recognised that prolonged intoxication, probably of alimentary origin, is one cause of arterio-sclerosis, and Dr. Bishop elaborates this view by ascribing all varieties of arterio-sclerosis to protein products of digestion or indigestion, which can become active only when the body has become sensitive to them through some peculiar change, an explanation of which leads him to have recourse to the hypothetical realm of anaphylaxis. On this view he bases his treatment, the essence of which is a protein-free diet.

The same number of the *Lancet* also contains a significant note anent the value of Tuberculin:—

The results obtained by the tuberculin treatment of phthisis at King Edward VII.'s Sanatorium during eighteen months have been made the subject of a preliminary report by Dr. Bardswell. His statistical results are subjected to a careful examination by Professor Pearson, who points out the manifold difficulties in their proper appreciation, and draws the conclusion that this treatment is still on trial and has not yet made good. Dr. Bardswell says quite frankly that his own experience, up to October, 1913, shows that the administration of tuberculin is quite unsuitable as a routine method of treatment for all cases of pulmonary tuberculosis, and that its indiscriminate and careless use on a large scale can only end in harm. He believes that many of those who use tuberculin do not at present realise the importance of avoiding all tuberculin reactions. His report is well worth reading.

All of which points to the conclusion that I am emphasising, *viz.*, that Nature abhors in-feeding (the predisposing cause of disease) or its equivalents, as we shall presently see more fully.

Prof. Richet thinks that the comparison between anaphylaxis and heredity opens a wholly new and unexplored field! So it does, provided we recognise that the deleterious effects of in-feeding begin to have cumulative and hereditary effects long before an actual outbreak of acute disease, and that the predisposition originates with faulty parental feeding habits, a transmitted diathesis.

The real differences between individual susceptibility and true anaphylaxis, it seems, cannot be strictly defined, *i.e.*, we may be dealing only with different degrees of susceptibility to poison!

Anyhow, "it is possible by physiological methods to modify the reactions of an animal in such a way that immediately after the injection of a poison it reacts just like an anaphylactised animal"; *i.e.*, an animal may show its reaction to poison at once instead of requiring a definite incubation period in which to deal with it.

What are the particular "physiological" methods which lead an animal to a sudden and violent reaction like that usually witnessed in one that was first "sensitised" by a poison (anaphylactised) and thus given time and opportunity to mature such a reaction?

"I have induced this condition," says Prof. Richet, "by means of profuse hæmorrhage. A dog which had been bled 4·3 per hundred of its weight (never fatal in a dog) was given 0·001 c.c. of crepitine, an amount never fatal in a normal dog even at the end of a month. Immediately its condition became miserable, resembling that of an anaphylactised dog. Here it would be absurd to speak of anaphylaxis; rather is it an instance of increased sensitivity, for which *the previous hæmorrhage may be held responsible*. It is clear that in certain states which we do not understand some individuals are more sensitive, although there is no question of spontaneous anaphylaxis." (*Italics mine.*)

The experimenter thus first diminished the vitality of the dog through bleeding and, though, as he avers, not fatally so,

yet on his own surmise just fatally enough to render the animal unable to cope with even a small dose of poison as gradually as it would in normal days. I cannot agree with Prof. Richet that he has here adopted a truly "physiological" method of modifying the reaction of an animal; but I regard it as an experiment in resistance to poison under conditions of anæmia. The difference of point of view also marks the difference of interpretation of anaphylactic phenomena in general. We have seen that Dr. A. Haig considers life itself as very largely determined by circulation. Hence, if you rob an animal of a great part of its circulation, you rob it of life and of powers of resistance. The principle is the same, I believe, as that whereby children of tuberculous parents are rendered more "sensitive," and whereby the lowering of temperature in a metal results in the lowering of its electric resistance—so that it now lends itself, as it were, more freely to electric "intoxication" by induction. The three main functions of the blood are: respiration, nutrition, and defence against invading organisms, all of which must be diminished in efficiency by bleeding. Let us see. In a discourse at the Royal Institution, 2/5/13 (*Nature*, 31/7/13), Mr. H. G. Plimmer, F.R.S., points out that the red corpuscles of the blood are the carriers of oxygen, acquired by the aëration of the blood in the lungs, to the tissues. They are, by far the most numerous, but their number varies enormously under the influence of parasites (*i.e.*, their number is connected with an either physiological or pathological condition of the blood). Amongst the white corpuscles are the Large Mononuclears—able to absorb and digest parasites and other foreign bodies (hence, again, on their presence *in sufficient numbers* the general resistance of the body must largely depend). The same is true of the Polynuclears. "In parasite diseases these corpuscles are profoundly modified and altered, *numerically* and morphologically, and other new elements may make their appearance in the blood." (*Italics mine.*) The numerical change easily becomes associated with

pathological change, which is also saying, in other words, that a disturbance of the domestic symbiosis has taken place, that bad (physiological) currency now takes the place of good, *i.e.*, that pathogenesis takes the place of symbiogenesis.

The mononuclear and polynuclear leucocytes are really separate organisms living in us, and they have qualities which it is very difficult to call anything else but consciousness; so that it is a subtle distinction to draw the line between the parasites—which these leucocytes are, in a way—which are part of us, and those that are not. When the balance of power is well preserved amongst our leucocytes, *when they are working well together*, then all is well with us. (*Italics mine.*)

The above experiment, therefore, seems indeed to be well calculated to prove that anything which diminishes symbiotics diminishes resisting power; that mutilations, though they produce reactions, are yet costly in vitality. The moral is that the way to avoid constant risks of being poisoned by even small doses of apparently harmless substances, and as the result of unavoidable minor mutilations, is to avoid every habit which produces physiological “*misère*,” and loss of integrity.

We must learn to rely upon integrity, health, and symbiosis rather than upon manipulations calculated to meet one evil by another.

The following are some of the leading principles of anaphylaxis:—

1. “A definite incubation period is necessary before anaphylaxis can be induced”; *i.e.*, as I would interpret it, when poisons, such as certain albuminous substances, are injected into an organism, the body is occupied to incubate (*i.e.*, to neutralise them) as best it can. This state may be termed a primary “infection” or “intoxication.” The operation “sensitises” the organism. A second injection (stimulation!) is generally required to bring the body to perform a violent effort of elimination (crisis). This is also called the “exciting” dose because it produces the anaphylactic shock, *i.e.*, the symptom that is the cause of so much perplexity.

“There are, in fact, two distinct groups of phenomena which must be differentiated. Firstly, there is *preparation* for the anaphylactic state—that is to say, the injection of anaphylactising substances, which we will call for simplicity *preparatory* substances; and, in the second place, there is the *exciting* of anaphylaxis by the second injection, with the production of the leading symptoms of anaphylaxis itself; we shall call these *exciting* substances.”

2. “The anaphylactic state lasts many weeks”; *i.e.*, on my interpretation, the incubation or “alloy”-formation takes time.

3. “There may be some similarity between anaphylaxis and immunity”; *i.e.*, both phenomena, I believe, represent a reaction to poisons, be it by neutralisation or by more or less pathogenetic adaptation, both of which must be at the expense of vitality.

4. “Anaphylaxis is to a certain extent specific; that is to say, the second injection should be of the same nature as the first”; *i.e.*, the reaction of the body is definite and apparently purposive to meet a definite contingency of which it has, as it were, received notice.*

5. “The symptoms of anaphylaxis are immediate and intense, while the symptoms of primary intoxication are mild”; *i.e.*, in my view the body, unable to meet renewed stimulation by further neutralisation of the poison and compelled to battle for its very life, proceeds to a violent effort, a violent “*élan*” to eject the impurities *in toto*. Having received a primary infection it is somewhat prepared to deal

* I do not deny, of course, that the healthy body can be made to react in a particular manner by means of inoculations. What I insist upon, however, is, that it remains to be seen in every case whether a genuine prophylaxis is thus to be contrived or whether the result is not in reality “*ana.*” *i.e.*, “away from” phylaxis, *i.e.*, pathogenesis. I insist that a special physiological investigation would be required in every case; such investigation to determine not only the immediate and expedient gains, but also the complete subsequent, latent and hereditary effects of the stimulations and changes involved. Who is Who?—physiologically and pathologically before and after the operation? What is the value of the inoculation in the sum total of racial vitality? These are the important matters that require urgently to be determined.

with the poison, and its general symbiotic powers so far as they are not yet impaired are summoned to a great eliminative effort.

The symbiotic forces, however, when they are habitually wasted on such "warfare," are turned away from their proper channels, and just as we have seen a weakening of the higher symbiotic powers of an organism to be the cause of a frequent over-emphasis of vegetative growth at the expense of sexual development, so every morbid "infection" (apart from its draft on vitality) may check "higher" development and lead to retrogressive adaptation.

Let us take as another biological illustration of the principle with which we are here concerned the case of the crab infected with a parasite, viz., *Sacculina*, as pointed out by Geoffrey Smith (in a paper read before the British Association, 1913). In crabs of both sexes so infected we do not find any of those cyclical changes of reproduction and of growth taking place such as occur normally in animals. Such crabs neither grow, moult, nor reproduce. What symbiotic powers there are in these hosts are too fully engaged in coping with the intruder—whom they must tolerate because they lack the power to expel. Sex and evolution consequently are sacrificed. The crab is thus forced into a retrogressive adaptation (a slow form of pathogenesis). It has to provide a larger percentage of fat than in the normal (cyclic) life, and its amount of lutein (connected with vital bio-chemical stimulation productive of cyclic changes, *i.e.*, with the general metabolism and thus with bio-economic function) in the blood is correspondingly diminished.

It has to satisfy demands which are exorbitant and therefore no longer symbiogenetic. Both organisms suffer from a distorted relation between demand and supply. "Ainsi l'histoire pèse lourdement sur la nature. Quand un organisme vit en parasite d'un autre, c'est le plus faible qui triomphe, sans qu'il y ait amélioration ni d'une espèce ni de l'autre. . . . L'excès de l'inégalité économique empêche les inégalités naturelles de se mesurer utilement" (Bouglé).

The crab is impoverished by the infection, and just barely contrives to achieve a miserable form of "immunity" from complete destruction by the sacrifice of its highest interests. In a similar way all attempts of the body to strike up a compromise with a poison, or with a vast surplus of waste matter, which amounts to the same thing, can only be carried through at the expense of vitality and of evolution. The alternatives are therefore either a violent or heroic effort to expel or destroy the enemy, or a weak compromise by pathogenetic adaptation with ultimate loss of status. What is shown on the biological scale in the crab is clinically demonstrated to be true of the animal or human system in a more acute form.

7. "The anaphylactising toxin affects the central nervous system, and the essential phenomenon is a disorganisation of this system, with a considerable fall in the arterial blood pressure."

Again, we have thus the pathological and pathogenetic effects strongly emphasised, and we are again reminded of the similar potency of the vegetable alkaloids and thus gain the clue to the deeper explanation of these ill-effects, viz., that they consist in the biological inadequacy of the substances concerned.

But there are other less direct ill-effects of these unsuitable food and other substances introduced into the blood both physiological and biological. The tissues of an animal are like the parts of an engine and must not be clogged or impeded by interfering substances, neither must the co-ordination (a kind of symbiosis) of the parts or the total energy required by this co-ordination be diminished.

In his work on *Leicester: Sanitation versus Vaccination* (p. 693), Mr. J. T. Biggs, J.P., quotes Metchnikoff as affirming that "the serum of the blood of many animals will destroy the red corpuscles of a different species," and Dr. Winters as saying that "horse serum dissolves human blood corpuscles and thereby produces new elements of decomposition."

Before albuminous (colloidal) food can be of any use at all it has to be largely converted during its passage through the alimentary canal into crystalloid form, in order that its constituents may find their way through the various membranes of the body to their respective destinations and may help to repair the waste of nitrogenous body material. Enzymes and ferments are instrumental in this process of breaking down, of simplifying and crystallising albumins, and they also assist in the re-conversion of these crystalloids into colloids when their diffusion would be fatal to the organism. We can thus see how any impairment of the general integrity of digestive functions and, indeed, of vitality generally must prevent and impede the continuance of many vital functions and lead to a further clogging of the system with foreign matter. Mr. Biggs quotes "a distinguished biologist" as saying "when once you interfere with the order of Nature, there is no knowing where the results will end," which seems indeed a very justifiable remark borne out by our study of anaphylaxis.

The direct injection of complex and heterogeneous albuminous and albuminoid substances into the blood is, in my opinion, a flagrant violation of the laws of albumin metabolism, seeing that the protective elaboration and conversion of these substances by the digestive juices is thus prevented. The blood is thus "ammonisized" and poisoned by substances with which it is ill-prepared to cope and which can only clog and deteriorate its operations.

A toxin is not always required to create anaphylaxis. "Several primary injections of normal serum into an animal develop an anaphylactic state."

"Anaphylaxis follows the injection of non-toxic and *harmless* substances; it is alone necessary that they be of an *albuminoid* nature." (*Italics mine.*) Certainly this should put us on our guard against albuminoids, which are nearly all of animal origin, and the "harmlessness" of which thus appears as very problematical, to say the least.*

* For Note see page 295.

"It is possible by intercurrent injections to prevent the appearance of the anaphylactic state"—"anti-anaphylaxis."

I should say, however, that the appearances are that this case merely amounts to a suppression of a particular form of symbiotic reaction against foreign matter, not to a real cure. We shall see later that Prof. Richet himself apprehends that frequently only a suppression of symptoms takes place. The probability of a similar conversion of certain wide-spread diseases into others has indeed occupied some of the more thoughtful amongst medical men.

"There is a form of anaphylaxis termed *passive*; that is to say, the blood of anaphylactised animals injected into normal animals produces anaphylaxis in them after a large number of injections, occasionally *after a single primary injection*."

What has the blood of one animal and in particular of a poisoned one to do in the veins of another? Is it surprising that the direct introduction of poisons into the blood or the spinal canal, thus escaping the safeguarding effects of the digestive process, should in effect amount to an artificial production of disease against which the body must constantly and vigorously react?

"In Paris alone, at a short interval of time, ten deaths have occurred which can be put down simply to injection of the serum into the spinal canal. These cases will multiply if a remedy is not found." (*Lancet*, 16/8/13.)

NOTE.—Thus we see from clinical evidence how the blood is "ammonised" by perpetual in-feeding and impaired in resisting power. The "soil" may well be more important than the germ. In the case of wounds, when progressive necrosis of cells occurs, it is not known to what an extent this is due to the direct action of specific toxins secreted by bacilli or to the action of injurious by-products formed in the decomposition of tissues already invaded by the bacilli. For instance amongst the by-products formed in the tissues is sulphuretted hydrogen which itself destroys red blood cells by its action on the iron of the hæmoglobin. (A. G. B. Foulerton, F.R.C.S.) The conclusion is thus again forced upon us that it is precisely a previous intoxication of the blood by habitual ingestion of animal proteids which offers the conditions favourable to virulence of microbic invasion (as in the case of the colon bacillus, the ally of senility) be it through ordinary infection or in the case of progressive necrosis from wounds. Similarly it remains to be seen to what an extent "wound"-fever is really "protein"-fever. The degree of dietetic protein-intoxication must largely determine the toxigenic production of fever in any distress of the body. The injurious effects of habitual in-feeding thus become specially emphatic on a break-down when the previous harmony of the heat-producing, heat-distributing and heat-restraining apparatuses is inhibited and an increased metabolism in the exposed tissues is indicated. The latter now easily become over-dosed with "combustible" proteid material and a general hyperthermia may ensue. Infection, toxigenesis, and hyperthermia may now easily become allies of progressive necrosis or of pathogenesis. We saw in the case of the "increased sensitivity" of Prof. Richet's dog, rendered anæmic through bleeding, how susceptibility and reaction may become acute under similar predicaments.

But surely prevention would be better than cure, and common-sense would suggest the wisdom of not injecting the serum in the first instance.

“Animals sensitised by anaphylactising substances are, to a certain extent, sensitised to all poisons, even crystalloids” (Ch. Richet, 1910).

If anything were needed to confirm the view that “sensitising” with “anaphylactising” substances generally and *per se* amounts to a weakening of the resisting powers and to a consequent loss of vitality, it is this passage. The case is the same as that of excessive pruning and of other mutilations which we have seen above to be injurious, but the ill-effects are here seen in acuter form.

The study of anaphylaxis thus, like that of so many other diseases, in so far as it is not a study of nutrition is in reality one of resistance. We should—and could, were we scientific and sensible enough—know the health and strength of a body in terms of resistance much the same as we measure the force of electricity by resistance.

The study of cancer has convinced some workers (*e.g.*, Macallum) that “the intolerance by the body of the disarrangement of its tissues is quite as wonderful as the growth of tumours and its study as illuminating.”

The same is true of anaphylaxis and, indeed, of all disease, be the symptoms whatever they may.

And what does this study of “the intolerance of the body” so emphatically disclose? Simply the fact that from beginning to end the body lives and thrives by symbiosis and has in course of its evolution painfully established a vast web of symbiotic safeguards and of *indispensable external symbiotic correspondences*, which are as essential to its well-being as the various resources of social life are necessary to the life of an ordinary human being. To interfere seriously with any important links is to throw the organism out of gear, although it has learned to meet a great many contingencies by new adjustments. Nay, it is more; it is to interfere with

the bio-economic efficiency of an organism on which, as we have seen, so much depends as regards both health and progress. Were the body tolerant of any serious disarrangements of its tissues, such tolerance would not only result in physiological impoverishment, but would also entail serious biological penalties—new “enemies,” new diseases.

Prof. E. Abderhalden (*Lancet*, 13/9/13) has pointed out the important protection given by the digestive mechanism. All complex substances which gain entrance into the system are broken down into simpler bodies, which again are subjected to the activity of the liver cells before reaching the general blood stream, with the result that normally the body cells receive “a nutrient supply of constant character.” This constancy is disturbed when the tissue cells or extraneous cells, such as cancer cells or micro-organisms, yield to the blood substances retaining some of the specific characteristics of *their source of origin*; *e.g.*, when they yield foreign substances of a non-reciprocal origin which the blood cannot use, nor break down, nor sufficiently discharge, and which must therefore remain and act as poison.

Even then, says Abderhalden, there exists an important means of protection in the lymphatic system, with all its extensions, and the organs of excretion assist in the protective processes by eliminating the poisons.

We thus see that the reaction of a body to disturbing influences is a very important matter, and is provided for by Nature in various ways, which show that it has been a major concern of evolution through the ages.

Dr. E. F. Bashford rightly points out that the problem of cancer should also be considered “from the point of view of the absence or withdrawal of resistance to growth,” and further: “In the development of an invasive tumour we have the subversion of the ordinary laws which we assume to govern the proportions and proper relations of tissue growth.”

What, then, is the principal law of which we must assume disease to be a subversion?

As all these considerations again confirm: *it is the law of symbiogenesis which provides for the most ideal form of self-preservation*, viz., that it is necessary for all parts and organs to co-operate in due degree in maintaining the tone and vigour of the whole organism, just as it is for all organisms in the biological whole to co-operate in due degree in their turn to maintain the world as we see it and to provide for its further progress.

To return now to anaphylaxis.

The incubation period, we are told, depends upon the dose, the type of animal, and especially upon the nature of the antigen used.

Again this is as we might expect it, particularly if, as I have stated, the course of disease in every organism must vary according to conditions of symbiosis and of resistance, i.e., of the general health of the organism.

Once "sensitised" it seems that organisms retain an increased susceptibility to the particular poison during their entire life. Indeed it would appear that a "sensitised" animal, like an "immunised" one, "*is no longer the same as a non-immunised individual*" (*italics mine*), even though otherwise apparently enjoying good health.

I should interpret this to mean that the "alloy"-formation required by the introduction of a poison has necessitated a permanent pathogenetic change in the domestic symbiosis of the individual, and that such change differentiates it once and for all from normal individuals.

Prof. Richet concedes that there are a few easily appreciated alterations in a "sensitised" individual. For example, there is always a definite leucocytosis.

"At the end of six months dogs injected with crepitine have 18,000 leucocytes per c.m., instead of 10,000, the normal figure."

This occurrence of leucocytosis practically confirms my contention that far-reaching pathogenetic changes are taking place in the system to cope with a poison, as it also indicates

a definite and costly activity in the direction of defence. The body has to increase its army of defenders, which means a general (symbiotic) tax and also a certain drain on its vitality, particularly as these phagocytic defenders may easily become spoiled, and from good servants turn into bad and exacting masters (*i.e.*, from scavengers they may become rank parasites).

“The *persistence* of the anaphylactic state during *so long a period* is one of the most remarkable phenomena in Biology, and it is certainly one of the *essential factors of individual differentiation*.” . . . “An anaphylactised individual is no longer the same as a non-anaphylactised individual. Even *alimentary ingestion*, by the *absorption of certain albuminoids*, or *microbic infections*, by the production of toxins in the blood and tissues, may produce anaphylaxis and immunity.” (Italics mine.)

And thus we get the apparently paradoxical proposition that an evil (“certain” albuminoids) introduced into the body produces at the same time disease and “immunity.” But on a closer view of the matter we find that this apparent contradiction is capable of a simple explanation. It is when the body only reacts passively that we get “immunity”; *i.e.*, the reaction involves only a pathogenetic change—a kind of latent anaphylactic state—without any immediate violent eliminative effort. With an active (acute) reaction to the same stimulation we get anaphylaxis. The two phenomena, therefore, though apparently so different in their results, are never really far apart.

What seems to puzzle the investigators most in anaphylaxis is the incubation period. But is there really anything wonderful in the fact that the carrying out of important symbiotic re-arrangements must take due time? We have seen that Nature makes no jumps, and that this is so precisely because generally a number of symbiotic correspondences are concerned in every change.

Further, in order to produce eventually a complete

symbiotic "élan" the body needs some preparation, *i.e.*, maturation or incubation to effect all the necessary simultaneous changes. If an organism is struck in its most vulnerable points it cannot afford to throw the whole burden of defence on that particular part, because it would interfere too much with the part's vital and highly specialised functions; but it must call to arms the whole symbiotic community. This general "mobilisation," of course, takes time. It is a well-known fact that many otherwise curable illnesses become fatal if sudden heart failure ensues, possibly because frequently the heart is too unprepared to meet sudden exigencies. Given due time and due warning even the busy heart, instead of breaking down, might have found it possible to give more assistance at the critical moment.

We may also infer from the above considerations what scope there is in a general way—through metabolic fluctuations, *i.e.*, through changes of feeding habits—for various possibilities of undesirable and pathogenetic developments.

We may ask indeed what is it that preserves the constancy of a species from the perils of promiscuous unions? Do not the phenomena of anaphylaxis indicate that there must be in Nature a great need of a definite and persistent principle, such as the symbiogenetic principle for which I contend, in virtue of which a species may be guarded against the dangers of drifting into pronounced pathogenesis? We have seen already that there is such a principle, and in view of these pathogenetic possibilities it is clear that the self-preservation of the organic world necessitated the establishment of some such principle.

As a further instance of lasting injurious effects produced by certain albuminous poisons, we get the following from Prof. Richet:—

A vegetable albuminous extract of *Hura crepitans* so alters nutrition that at the end of three months the animal still shows the effect of it; in general, dogs on which I have experimented do not completely regain their former weight.

This example also brings us again near that prolific source

of much trouble, viz., the biological inadequacy of certain substances as food. The effects as they are here described show that the particular extract forms a disturbing element in the dog's physiological economy. We have seen that the biological adequacy of food rests upon a genuine symbiotic basis, a basis of give and take and not one of promiscuous appropriation. This symbiotic basis which has established itself in course of evolution is the true safeguard of all health and progress, and, in its absence, no amount of artificial interference will ever adequately compensate for the lack of proper relations.

The symptoms of anaphylaxis are essentially the same in man and in animals, and this shows that we are entitled, broadly speaking, to draw the same general inferences as regards the value of feeding and of food substances in either case.

What generally happens is this:—

The arterial pressure is lowered, more or less, according to the general intensity of the reaction, and there is intestinal congestion. . . But if anaphylaxis is profound, they [the symptoms] assume a very different aspect. In this case there is no pruritus. The earliest effect, the first symptom, is a frequent vomiting, so prominent that in a number of cases it develops at the end of ten seconds or almost immediately after the injection even of a very small dose. This vomiting is so characteristic that I have taken it as a criterion more easy to observe than the fall in blood pressure. It may be said that it is never absent except in some very rare cases of extraordinarily intense anaphylaxis. In these the animal is immediately in such a state of prostration that it has no strength to vomit. The vomit is frothy and mixed with bile; sometimes it is faecal, and sometimes, in the severest cases, mixed with blood: for, from the beginning, there is an intense gastro-intestinal congestion.

It is thus evident that we have here a violent eliminative attempt on the part of the body, a crisis which taxes its symbiotic powers. The success depends on the degree of vitality and on the state of the eliminative powers ("strength to vomit") in the particular individual.

One of the military reserve forces in Continental countries (now so prominently before the world) is called the "Land-

sturm." It is to be called up as a last resource, when everything else is in danger of collapse and other defensive forces are already in a state of exhaustion. Similar defensive preparations exist in the polity of an organism, and they are called up to a "storm" (an eliminative crisis, a last symbiotic "élan") when an enemy threatens the penetralia of communal existence, *i.e.*, when such safeguards as digestive and symbiotic momenta are avoided or put "hors de combat."

But frequently the outburst of nervous symptoms is so sudden and so violent that the colic and diarrhoea never appear. Ataxia rapidly supervenes; the animal staggers as if it were intoxicated; it becomes paraplegic, drags the hinder part of its body, and does not raise the toes of its fore-paws, thus resembling those animals whose Rolandic convolutions have been destroyed. The pupils dilate and the eyes are dulled, while the animal passes urine and faeces, becomes exhausted and insensible, and fails to respond to any reflex stimulations, and assumes a state of complete mind-blindness. Respiration is quickened and dyspnoëic; the arterial pressure is very low, scarcely 4 to 5 c.m. of mercury. The heart hurries its beats, which are so weak that sometimes they can scarcely be counted. Fæcal matter, fluid, diarrhoeic, and blood-stained, pours from the rectum without the animal perceiving it. Breathing soon becomes so harassed that death from asphyxia seems impending. The general condition is serious enough to believe death imminent, but in reality death in less than two hours is extremely rare in the dog. Esredka has rightly called this sudden alteration of the nervous system *anaphylactic shock*.

Here we have a vivid description of a kind of physiological "Land-sturm" in operation. Evidently the whole of the body's symbiotic powers have been called into action. It is a supreme test of, but also a severe tax on, vitality.

We are also justified now in drawing a parallel between this "anaphylactic" endeavour of the body to eliminate impurities and Mendelian segregation. The symptoms of incubation in anaphylaxis and of "immunisation" with the formation of an "alloy" are comparable to those of Mendelian hybridisation when, say, a diseased strain is crossed with a (more or less) healthy one, as a result of which the formation of a genetic "alloy," *i.e.*, of a damaged F¹ generation ensues. As soon as a second opportunity is provided for

an eliminative symbiotic "élan," by a renewed identical infection with poison in the anaphylactic case, and by a renewed identical "infection" through fertilisation, *i.e.*, in-breeding, in the other, a "crisis" purporting segregation (elimination) ensues. The "alloy-formation" (the apparent tolerance or "immunity" in the one case, as the apparent blend in the other) is only preliminary and temporary, the state of latent anaphylactic intoxication being analogous to the unstable and damaged F¹ generation. The sequel in either case is segregation, *i.e.*, elimination.

It is clear from an analysis of the symptoms that the anaphylactic poison, which we shall call *apotoxin*, poisons the central nervous system, as I pointed out in 1902. Everything is indicative of this: the immediate vomiting, the ataxia and vertigo, the dilation of the pupil, the mind-blindness, and the vaso-motor paralysis. Apotoxin acts upon the medulla and the highest nerve centres, which, in all cellular organisms, are well known to be the most sensitive to the action of poisons.

Again, what emerges is this: when a poison has penetrated the ordinary defensive forces of the body, only a supreme symbiotic élan on the part of the "reserves" of the body can cope with it. *Apotoxin*, or some such poisonous substance, is formed by way of compromise, capable of producing such supreme effort through its actions upon the highest nerve centres. Like a nation the body is intent upon maintaining its individuality at all costs, though frequently when they have sinned too long, nations as well as organisms succumb in the final effort. It is pathetic that frequently in the history of individuals, as in that of nations, nothing but imminent danger (war) will call forth progressive symbiotic efforts. But nations as well as individuals, if there is any nobility left in them, may provide in the last hour a symbiotic endeavour which they sadly lacked in the days of prosperity. It is like a death-bed repentance.*

* "The life of a nation is usually, like the flow of a lava stream, first bright and fierce, then languid and covered, at last advancing only by the tumbling over and over of its frozen blocks. (All men being partly encumbered and crusted over with idle matter!) And that last condition is a sad one to look upon."—RUSKIN.

It is with disease and symbiosis, as it is indeed with might and right: "C'est la force et le droit qui règlent toutes choses dans le monde; la force en attendant le droit."

What happens in the case of the body is that some of the protoplasm of the neuron cell enters into a new chemical combination with the poison ("nervous intoxication"), and that the body is thus precariously stimulated to do new and wonderful things; amounting in essence, as I have said, to a defensive symbiotic "élan," frequently of a revolutionary order.

Whatever the antigen injected may be, if the second dose is of the same nature it induces anaphylactic symptoms, and these symptoms are practically the same. Whether mytilo-congestine, suberitine, actino-congestine, or crepitine be used, the same group of organic reactions always appears, so that one is tempted to think that the same terminal poison, *apotoxin*, is invariably produced.

It seems equally clear that the identical reaction is invariably produced. It is at any rate certain that in each case a "nervous intoxication" is produced. It is possible to "suppress" nervous intoxication, for instance, by means of anæsthetics. But if the protoplasmic reaction to a poison is thus suppressed we must suspect that the case really becomes more aggravated, and that the poison remains to undermine the constitution in other ways. The case recalls the loss of an organ of sense, say smell. Nasty smells do not apparently affect a person so afflicted, but the power of protection and of warning normally afforded by the power of becoming "sensitised" by nasty smells is gone and the liability of the person to disease is in reality increased, and the individual may be severely handicapped in life, through the suppression of its power of reaction in that particular direction.

The same argument, viz., that an interference with the general integrity of the body must lay it open to fresh dangers may be said to apply to the following of Prof. Richet's remarks:—

The blood certainly undergoes important chemical changes; but their nature is unknown to us. We are only acquainted with its morphological changes.

What with the obvious occasional ill-effects of serum injection, the doubtful effects of others, and our ignorance of the nature of the important changes thereby set up in the blood, we certainly do not seem to be warranted in trusting to such means for the preservation of our most vital symbiotic momenta. It is a case where we should "rather bear those ills we have, than fly to others that we know not of."

Is not the normal constitution of the blood correlated with a vast number of definite requirements for the protection of the body? The structure of the blood is far from being thoroughly known, and the more it is studied the more complex it becomes. Does it not, therefore, amount to a serious and almost incalculable disturbance of the physiological equilibrium if we interfere in a haphazard manner with the all-important normal composition of the blood?

Prof. Richet states his own belief that "the blood being toxic (after injection) it becomes powerless to maintain the life of the nerve-cells." In a similar way, according to my view, perpetual in-feeding causes a pathogenetic abstraction from, and a poisoning of, the blood and undermines the highest nerve-centres which eventually leads to atrophy of the brain. I have already stated that a kind of irregular growth is gradually established as the result of inappropriate food stimulation (such as the antithesis between growth of brain and of the canines in carnivora!), and we can see that without the protection of the digestive process this pathogenetic process must proceed at a much quicker rate. The organism that has to satisfy the exorbitant claims of huge teeth and fangs—with a pathogenetic impoverishment of the blood—has less pabulum to spare for brain, and it is the same with protoplasm that has to form *apotoxin* (pathogenetic "alloys"), particularly so as in its manufacture the bio-chemical laboratory of the brain has to be resorted to and to be taxed to the utmost.

It is in connection with anaphylaxis in man that Prof. Richet speaks of "serum disease," and he tells us further (as mentioned above):—

It must be noted that in certain instances a first injection of horse serum is quite capable of inducing such symptoms as urticaria, arthritis, nausea, vomiting, œdema, pruritus. It has even been stated that normal horse serum, the serum of horses not immunised with diphtheritic toxin, can produce symptoms in predisposed individuals.

It is thus clear that some persons are already predisposed by an in-feeding diathesis (equivalent to a latent anaphylactic state, as I should interpret this to be) to anaphylactic shock. Indeed, some such explanation seems to suggest itself to Prof. Richet, as the following passage bears out:—

It may therefore be asked if there is not such a condition as spontaneous, natural, or idiosyncratic anaphylaxis. But the word idiosyncrasy explains nothing; it would be better to suppose *that there was such a condition as special anaphylaxis induced by diet*. This would practically account for the fact that symptoms invariably follow the first injection of horse serum into those who, for therapeutic purposes, take a raw horse-flesh diet. (Unpublished work, de Rist and Ch. Richet, junior.) Certainly some individuals who have never eaten raw horse flesh are sensitive to a first injection of horse serum; but the more or less rigorously specific limits of the anaphylactising antigen have not yet been so defined as to enable us to say that there were not *in their diet substances capable of developing a special anaphylactic state* against horse serum. Therefore, this statement, which has been formally made, appears to us of very great importance in proving that an undoubted anaphylactic state to horse serum can be induced *by horse-flesh diet*. (Italics mine.)

Prof. Richet thus tells us in other words that in-feeding generally may easily result in liability to serum-disease, which merely becomes more acute upon a single injection of the serum of the particular animal the flesh of which has been consumed.

I fully concur with Prof. Richet in supposing that there is such a condition as “natural” anaphylaxis induced by diet, although I believe I have termed this condition with more accuracy and biological justification a “parasitic diathesis.”

Some anaphylaxis investigators have coined the term *allergy* to mark the phenomenon of reaction of an organism to a foreign substance. It remains then to tabulate all disease in terms of “allergy.”

There is a local as well as a general anaphylaxis. . . It certainly is not one of the minor difficulties of the question to find, not only the blood and viscera, but all the tissues, skin, and lymphatic glands saturated with the poison.

Prof. Richet tells us:—

Since in all these cases of anaphylaxis in man the injection has never been given intravenously, and nevertheless the symptoms have been very serious, and since a large number of experiments on animals have proved that intravenous injections induce more rapid and more intense symptoms than subcutaneous injections, it can be concluded definitely:—

1. That *man is extremely sensitive to the anaphylactic reaction.*
2. That intravenous second injections invariably constitute an actual danger.

Verb. sap. sat.

As regards the anaphylactising substances, Prof. Richet tells us that:—

Up to the present everything seems to prove that colloids alone are able to induce it; just as colloids alone are capable of producing the reactions of immunity. . . . Innumerable investigators have shown that it follows the injection of heterogeneous sera such as ox serum, eel serum, goat serum, without exception.

In previous chapters we have already seen that for biological (bio-economic) reasons the use of colloids must be qualified, that it is only certain groups of colloids that play a prominent part in the evolution of taste and of smell, and that other albuminous substances easily give rise to overstimulation with resulting fatigue and to inductive decomposition. It is perhaps in no small measure due to their inability to react upon such important guardians of integrity as the organs of smell and of taste that insipid colloids are so apt to be indulged in to excess, and thus further to pervert the sense of proportion. Being insipid they require to be mixed with sapid substances, and it is as a means of obtaining at least a modicum of such sapid substances, and of vitamins which are only secondarily associated with such colloids as flesh-foods, that an in-feeder, as we have seen, is frequently obliged to go to excess. But there is no compulsion upon organisms to resort to these questionable colloids for food supplies, for

Nature has supplied an abundance of materials to which these objections do not apply in the shape of "love-foods," which are as ideally useful as these other foods are injurious.

The poisonous effect of "heterogeneous sera" bears out very strikingly the thesis that a definite kind of food is required by every organism; that is, I submit, food derived in virtue of symbiotic activities. An animal does not (normally) want the life nor the substance of another for its fare. It does not even want the whole of a plant. It only wants parts—parts which can be spared by the plant without serious injury, which is a different matter from wholesale depredation. In short, I submit that the above examination of the phenomena and rationale of anaphylaxis again shows us that those *substances which the highest symbiotic activity of the plant can produce, and well afford to exchange with the animal, constitute the most valuable, the most ideally proportioned foods for the animal, and I regard this as the fundamental principle of scientific nutrition.* This truth may be unpopular and unpalatable to many, but my concern is only with genuine science, which is not always the same as "popular" science, and which without bias rests its judgments upon the evidence adduced.

I hold that what applies to the plant and to the great problem of production by the plant, applies with equal force in the case of man. The case of the plant and of "production in agriculture" is put thus by Mr. A. D. Hall, F.R.S. (Brit. Assoc., Brisbane): "The desirable method is to keep the plant free from disease by means of a *naturally* resistant constitution, and by establishing *healthy conditions of soil and nutrition.*" (Italics mine.) He also tells us:—

What is needed is not a field experiment merely, but a discussion of a whole system of cultivation on the economic as well as on the scientific side. This suggests the general consideration that economic research in agriculture is still in its infancy.

With all this I concur; but I demur to Mr. Hall's attitude that nutrition may not be scientifically studied because our

modern dominant races "will insist on remaining flesh-eaters even if that necessitates the limitation of their own numbers," and ask from science for nothing more than the most expedient means of producing fat "stock" for culinary purposes.

Denn aus Gemeinem ist der Mensch gemacht
Und die Gewohnheit nennt er seine Amme.

It does not seem to me to be in accordance with the noblest spirit of Science—the Cartesian spirit which appealed to Huxley—to be degraded so as to be nothing more than pandering to the perverted tastes and wasteful instincts of modern town populations. It does not appear to me to redound to the credit of Science that a representative scientific man can declare with a great measure of truth that the important question of the wasteful conversion of plant food into animal food by pasturage, rather than encourage a cultivation more concordant with the true needs of humanity and of organic life generally, cannot be broached because of our gross and dysgenic modern feeding habits.

"The scientific man has at present little to say to this sociological question." Meanwhile, I suppose, we shall continue submitting to artificial limitations of population, to a vast amount of social evil and discontent, and likewise to an occasional mutual throat-cutting, in order to reduce population and bring it more in accordance with the demands of our dysgenic instincts.

Well may they fear some miserable end,
Whom gluttony and want at once attend.

How can we hope to solve the greatest problem of agriculture, viz., in Mr. Hall's own words, "how to increase the duty (!) of the leaf so that it shall effect a greater production of dry matter for the amount of light energy it receives," without knowledge of what constitutes scientific nutrition? Failing such knowledge, as we have now seen on so many counts, every great biological and sociological problem must remain more or less enigmatical—a veritable riddle of the Sphinx in Huxley's words.

We have seen that wrong feeding in man and beast leads to "ammonisation" and impoverishment of the blood, to numerous concomitant disturbances of function, to a superabundance of waste-matters, prone to quick decomposition, and providing the soil for a pestiferous growth of a pathogenic intestinal fauna and flora. Such vitiated "soil" reacts unfavourably (through our manurial and pasturage system) upon the microbic composition of the agricultural soil and, hence, upon vegetation. The soil, infected and dyspeptic by unclean alimentation, favours the virulent growth of pathogenic at the expense of symbiotic and useful (nitrogen-fixing) micro-organisms. The diathesis of man and his beasts thus induces a vicious circle affecting the soil-flora, the soil-fauna, and, in turn, his own species.

Our water-supply likewise, for the same reasons, occasionally becomes poisoned with the result of various diseases and epidemics. Our own wars—very "terrible medicine" for our biological transgressions—produce depopulation, which means throwing land out of cultivation.* Uncultured land breeds disease, and this in turn causes further depopulation. "The land is defiled by iniquity and it vomiteth out her inhabitants." It all goes to show, again, that we "sensitise" and predispose ourselves for the gravest disorders by wrong feeding and various concomitant remedial courses long before we usually invoke "serum-therapy"—which is beginning at the end of the problem. Nor is it by any means that the blame rests mainly with our physicians. And this brings us back to the consideration of anaphylaxis.

We have seen that it is a biological adequacy—the symbiogenetic use—which must qualify the use of colloids and, for the matter of that, of all food substances.

The very fact that among definitely crystallisable substances certain vegetable alkaloids, such as quinine and antipirin, form exceptions and sometimes do produce

* The view expressed in some quarters that wars often are due to a kind of collective fallacy—if not a collective insanity—seems indeed amply justified.

anaphylactic sickness, again indicates that it is less the morphological state than the biological potency of organic substances that is responsible for the effects observed.

It appears that the anaphylactising substances are chiefly albumins and globulins from serum (albumins from white of egg), and, further, that no chemically-formed substance can be anaphylactogenic, which again seems to suggest that it is mainly a biological antagonism with which we are here concerned.

Peptones lie between colloids and crystalloids. Some believe that the phenomena of anaphylaxis are due solely to peptones. Others conclude that they are due not to albumin itself, but to certain of its cleavage products, probably analogous to peptones. "Cleavage-products," like other decomposition-products of proteins (alkaloids!) may be anything but desirable "building-stones."

Many of the albumins of ordinary fare require a considerable amount of breaking down by the digestive juices, a task sometimes beyond their power. The blood seems to require simpler and purer substances, such as the plant is able to manufacture in ideal perfection. Fruits, except when over-cultivated and especially surfeited with manures, have not been known to produce the anaphylactic state. Thus again we see the ideal adequacy of "love-foods"—free from impure and non-reciprocal, and, therefore, obstinate and antagonistic "cleavage-products." Albumin of animal origin, because of its lack of biological reciprocity, thus is at best but second-hand food and bound to cause various troubles. Prof. Richet tells us that "as long as the albuminoid molecule is not completely destroyed, even when it is extensively broken up by tryptic digestion, it remains capable of producing anaphylaxis."

If it thus taxes the strongest powers of digestion to deal with (animal) albumen, how much more certain is it that a direct injection into the blood stream, particularly in cases of already debilitated vitality, must have poisonous effects. The

danger of a non-reciprocal foreign substance becoming dominant (prepotent) can only be met by a supreme effort of the "Land-sturm" above referred to.

Prof. Richet states that in anaphylactising substances we are not dealing with pure homogeneous products, but rather with mixed substances.

Obviously when using horse serum we are using a very complex substance. Congestines obtained from actinaria, from *Hura crepitans*, although more homogeneous, are nevertheless mixtures of very similar substances which it will be found difficult to separate.

Evidently we are here dealing with substances that are far too complex to be valuable, and, what is less obvious but rather more important, with substances that are biologically inadequate. On the one hand such substances introduce much foreign material difficult to get rid of, and, on the other hand, their ingestion must frequently lead to deficiency diseases; more pronouncedly so when through direct injection into the blood the defensive forces of the digestive tract are put out of action and rendered useless. An animal uses up the valuable ingredients derived from plant food in its own life-processes, and its serum must contain decomposition products difficult to break down further, and vitamins, if at all, robbed of some of their constituents. What is human blood to do with such fare except to protest against its intrusion?

Prof. Richet makes certain very tentative suggestions as regards the possible composition of these sera, and he thinks that Bio-Chemistry will probably enlighten us one day as to the real properties of the various groups of albuminous substances here concerned, *i.e.*, "Bio-Chemistry will have the final word in the matter."

It seems a fair inference that we are here dealing, however, with a general and biological inadequacy, and that it is in reality Bio-Economics that will have the final word in the matter. We are also justified in inferring that the whole case of serum-disease confirms my oft-repeated bio-economic dictum that Nature abhors perpetual in-feeding. Indeed, the

experiments under the head of anaphylaxis may be viewed as providing striking tests of this important evolutionary law. They show by their results that, though an in-feeding mode is possible for a while under reliance upon symbiotics with apparent impunity, the blood is in reality all the time obliged to protest against the biological unsuitability of such food, and to make many even pathogenetic concessions, whilst all the time the eliminative powers are being taxed to breaking point.

It seems that sometimes anaphylactic phenomena are interchangeable. If one of two poisons is used for "sensitising," the other may be used for "intoxicating," which again seems to indicate that the first method has induced a kind of pathogenetic convergence; *i.e.*, the body is now predisposed to reaction, and various kindred poisons when super-injected are now capable of precipitating the identical reaction, of pulling the trigger of reaction, as it were. "The anaphylactic phenomena, however, are most often rigorously specific, so much so that it is possible to distinguish anaphylaxis brought about by ox, sheep, dog, or human blood; by cow's, mare's, or human milk, etc., with such a degree of accuracy that this process of diagnosis might be made use of in forensic medicine."

As a rule, then, the blood makes a definite and pronounced protest against the introduction of every biologically unsuitable and antagonistic substance, and that this is so is significant also as an object lesson regarding feeding, the reactions there being merely much slower.

In the case of sera acting as anaphylactising substances "following stronger doses, anaphylaxis takes a longer time to appear." I should explain this again as meaning that with strong doses a considerable amount of pathogenetic activity for "alloy"-formation is required, and that this necessitates a considerable period of incubation.

Prof. Richet interprets it thus:—

It seems that anaphylaxis can only develop when all the preparatory substance has disappeared.

But how has it disappeared, and what are the bio-dynamic concomitants of such disappearance? That is the question. As we cannot presume the preparatory substance to have vanished into thin air, it must have been neutralised and, we must presume, at considerable cost of vitality, by the body. It is not until this process of neutralisation ("alloy"-formation) is completed that the body's preoccupation has gone, that it can proceed to a more drastic operation, which nevertheless purports purification, viz., a symbiotic "élan," or the "anaphylactic" crisis. Though this is intoxication, yet there is method in it! In order to bring on the anaphylactic condition, "Usually the *exciting* dose should be stronger than the *preparatory* dose," which somewhat speaks for itself, for it seems hardly worth while for the body to run the great risk of the anaphylactic crisis except under great urgency.

Prof. Richet tells us that while seeking a biological reason for, and the final cause of, anaphylaxis, he was led to suppose "that animals acquire this extraordinary sensibility in order to be able, during the anaphylactic period, to resist any further effect of the poison. With certain substances, as, for example, mytilo-congestine, anaphylaxis diminishes markedly towards the fortieth day, and the state of immunity establishes itself." He adds, however, that this seems less probable to him to-day. Some organisms are more accommodating no doubt for poisons, as for pathogenesis generally, than others. Some develop resistance better and quicker than others. But this is not yet a biological explanation of the deeply-founded antagonism with which we are here concerned. Nor have we here a genuine immunity, but only a specific and temporary one—pathogenetically come to—and in reality rendering the condition of the organism precarious, mainly because of the costliness of the new "adaptation" in other directions. A sensitised individual, as we have seen, is never the same again, however much it may have succeeded in neutralising a certain poison.

Doerr and Raubitschek have observed the same phenomenon with eel serum. The simultaneousness of anaphylaxis and immunity in the

injected animal leads to a curious result. If a fresh animal, and one previously injected, be given the fatal dose of crepitine, as crepitine only kills in from ten to twenty days, and a first dose never produces immediate effects, the fresh animal is not affected by the injection; it remains bright, alert, and does not seem to have received the least trace of a toxic substance. But the anaphylactised dog is extremely ill; it passes bloody motions, and suffers from vomiting, ataxy, and mind-blindness, so much so that it appears to be dying. But frequently it recovers, and the next day appears in almost as good condition as the other dog. After ten or twelve days the latter becomes cachetic, paralysed, and wretched, and dies; the anaphylactised and not immunised dog in the meantime gains perfect health.

This experiment, although apparently paradoxical, is absolutely beyond doubt, and I have repeated it a great number of times. (See *Physiological Lab. Rep.*, 1902, v. p. 514.)

Thus we see not much more than that (normally) a fatal dose is fatal, which is not exactly "paradoxical," although (abnormally) the anaphylactised dog "frequently" recovers. Where it does "recover," this proves that through being previously given an opportunity of meeting a particular poison, it is able by dint of an adequate incubation period, and in virtue of a sufficient fund of vitality, eventually to cope with even a stronger dose of poison. The second dose now stimulates it to a supreme, and somewhat prepared, symbiotic effort at elimination. But, as good economists, we must not omit to count the cost, nor forget the fact that we have here a pathogenetic process which goes on at the expense of vitality and of survival-capacity.

What about the dogs that do not "recover"? We must assume that for some reason or other their vitality failed them during the supreme test.

The non-anaphylactised dog, not being a quick-change artist, being taken by surprise as it were, cannot meet the poison even by a pathogenetic change and dies—always a convenient way out of sudden difficulties.

The dog which has successfully weathered its anaphylactic shock has also, it appears, got rid of its "immunity"—a result on which it is to be congratulated, seeing that

“immunity” is but a state of latent poisoning awaiting correction by some kind of costly elimination, if it is not to lead to rank degeneration. For, as Prof. Richet explains “without difficulty,” “there are formed simultaneously in the blood antitoxins for immunity and toxigens for anaphylaxis.”

If the blood is thus becoming laden with all possible poisons, antitoxins for neutralisation purposes, and toxigens for eliminative purposes, how is it to perform its usual and normal functions? How is it to maintain a desirable degree of vitality and of resistance in other directions? Once more, happy the dog that gets rid of “immunity.” Happy he also that dies of anaphylaxis.

For whoso lives, as I, in many woes

How can it be but death shall bring him gain?

Immunity or anaphylaxis is observed according to the strength of the *exciting* injection, immunity following weak doses and anaphylaxis following strong doses.

In other words, as I have already apprehended, with weak doses the body is content to continue the neutralising process rather than risk a supreme crisis. But with a strong excitation it is forced to react violently.

The fact that “there are very great individual differences in the sera of animals treated in exactly the same manner,” again shows that the constitutional differences between various individuals are many, and that, hence—

Eines schickt sich nicht für Alle.

“Passive anaphylaxis” (*i.e.*, as I would say, latent poisoning, unrelieved by an eliminative crisis) “has been observed in the dog, the rabbit, and guinea-pig. In the dog it does not merely manifest its presence by immediate effects, but also by chronic secondary effects. Occasionally the dog is not very ill after the *exciting* injection; nevertheless it dies sooner than a normal dog and as the result of weaker doses.”

It is precisely these “chronic secondary effects” which, in my opinion, are so important. Obviously they indicate that a general pauperisation is the result of these injections, and that

resistance is being weakened in many quite unforeseeable directions.

The proposition of "alloy-formation" which I have advanced receives considerable support from the following:—

Moreover it may be admitted that toxigen is fixed in some organic tissue and only appears in the blood when in great excess. Apparently it becomes localised in the cerebral tissue, and it is obvious that in certain cases there is too little in the brain for it to be diffused in the blood though there is enough to cause the animal to react to an *exciting* injection.

The brain thus, so long as it is not overdosed, vicariously protects the general blood stream from the poison. To what an extent it is thus pathogenetically prevented from discharging its vital bio-chemical functions in other (positive) directions remains to be seen. That there is a limit to its neutralising powers becomes evident in the effects of the "exciting" injection, when the body is left to protect itself as best it can, and when the general distress of the brain becomes also very apparent (mind-blindness, etc.).

The toxin injected into the blood is fixed in the brain, to disappear slowly and be transformed into toxigen. Toxigen can therefore be considered an endotoxin fixed in the cells, especially in the nerve-cells, and it is suddenly transformed into extremely toxic apotoxin at the moment the toxin comes into contact with the cerebral cells.

Evidently, then, an "alloy"-formation takes place, and this toxigenesis is well on the way to pathogenesis. *Inde caput morbi*. Either the vitality of the body is slowly undermined or there is a striking instability; in which certain nitrogenous matters are thus again seen to play a prominent part. With any sudden and pronounced dominance of the poison an "explosion," *i.e.*, an acute sudden revolt of the body (an anaphylactic shock) may be started.

(The supposition is "that apotoxin is very unstable and disappears quickly after its formation.")

It seems that what is termed "anti-anaphylaxis" can be induced by "repeated and massive doses"; *i.e.*, the symptoms

of anaphylaxis are suppressed and elimination rendered impossible by over-poisoning of the system. The healthy (symbiotic) endeavour of the body is suppressed and for a time it remains in a sullen state of "immunity," *i.e.*, of increased pathogenetic tension. Or is there anyone naïve enough to believe that repeated and massive doses of poison can really be better than rare and small doses? *

Such "immunity" to anaphylaxis, Prof. Richet thinks, "is quickly established in some cases in an hour and a half." "Anti-anaphylactic immunity conferred by an injection made in the pre-anaphylactic period may last three months."

However, neither the brain, liver, spleen, nor serum can transmit "anti-anaphylactic immunity," which again makes us suspect this kind of "protection," for it seems that it is easier to transmit the predisposition to serum disease to offspring than to transmit the extremely doubtful kind of "protection" conferred by "anti-anaphylaxis."

Prof. Richet, of course, only quite impartially records results of scientific experiments. He is by no means narrow-minded, but open to other considerations. He suggests that it is possible to explain the results of repeated and massive injections "by other hypotheses than anti-anaphylaxis."

Thus in criticising the view that calcium chloride injections give "immunity," he points out that "calcium chloride is only effectual in antagonising anaphylaxis in extremely strong, almost poisonous doses."

Or, more outspoken sceptical still: "All poisons of the nervous system, like ether and chloral, in Besredka and Roux's historical experiments, are in themselves anti-anaphylactics; I would preferably call them pseudo-anti-anaphylactics; they

* Sir W. Watson Cheyne protests against the introduction of vaccines on a gigantic scale and apart from a strictly prophylactic use. In his Hunterian oration he says: "The fact that the disease is present shows that the natural immunity of the body has been more or less overcome. If the quantity absorbed from a wound has broken down the resisting power of the body, how can it be restored by the subsequent injection of more toxins from a flask? I know that bacteriologists try to defend their position, but the arguments put forward in its support are purely theoretical and very obscure." . . . "I have seen lesions getting well in a part of the body and yet, while still under vaccine treatment, fresh lesions breaking out in other parts of the body, and I have also seen bad and even fatal results follow the use of vaccines." Evidently we cannot play fast and loose with our resisting powers.

merely *prevent anaphylaxis by paralysing the reactions of the nervous system.*" (Italics mine.)

In other words, the organism is foiled by large doses of poison in its wholesome attempt at eliminative reaction. We may conclude that this amounts to a very serious handicapping of the organism's vital symbiotic powers generally.

"Pseudo-anti-anaphylactics" means, in other words, that the cure is worse than the disease.

The *Lancet* (13/9/13), in reviewing Prof. Richet's book, does "not feel sure that the usage (of the word anaphylaxis) is correct, in that the subject of it develops not immunity, but increased susceptibility to a poison."

I believe I am on solid ground in classifying the phenomena here concerned under the head of Pathogenesis, a term that Prof. Richet himself employs, on p. 183 of his book when referring to some important morbid symptoms, which, as he says, "have not hitherto received rational explanation."

First among these unexplained morbid phenomena is the "extraordinary" sensitiveness of some individuals to certain foods. "The eating of certain foods: pig meat, hare, strawberries, asparagus, mussels and shell fish, leads in certain people to obvious symptoms."

We are thus arriving at the true *fons et origo* of most morbidity, *i.e.*, the unfitness of certain substances for assimilative purposes as due to a biological antagonism arising from certain modes of feeding, and this for the reason that these modes interfere with that system of elaborate service of one organism to another, on which all evolution is primarily based. As I have also expressed it in my paper on Biological Economy before the British Association (1912): "The in-feeding habit by causing metabolic abnormality is detrimental to mutual aid."

Food that is thus biologically inadequate must eventually become physiologically inadequate, *i.e.*, poisonous, however "nitrogenous" and even plant-manufactured it may otherwise be. The similarity of many vegetable with animal metabolites

shows that in both kingdoms the identical (hereditary) diathesis frequently obtains and is apt to convey morbid infection to a whole round of biological relations. Thus allantoin, a body analogous to urea, which is known as an important waste product of the vertebrate embryo, is also found in quantity in the opening buds in spring; and pepsin can be obtained not only from the stomach, but also from the digestive secretion of the insectivorous plants.

We have seen that useful vitamins may be converted into poisonous alkaloids, and that the plant proceeds in its pathogenetic alchemy in proportion as it is subjected to depredation, instead of obtaining reciprocity for its inestimable services. In short, we found the Bio-Chemistry of both plant and animal to be determined by reciprocal bio-economic factors; the adequacy and legitimacy of food also depending on the identical symbiotic factors.

To eat pork, hare, and shell fish is certainly not in accordance with the grand symbiotic division of labour which has established itself as the normal rule of life, demanding cross-feeding in the best interests of this symbiosis. Such habits are, on the contrary, opposed to the normal order, and result in an inferior physiological currency establishing itself at the expense of a nobler currency. This cannot lead to symbiogenesis, but must lead to pathogenesis. At any moment during this process, according to varying degrees of resistance, the dominance of the poison (every surfeit of inadequate substances must eventually turn into poison) may assert itself and cause violent reactions. In other cases pathogenetic compromises may proceed for considerable time before the organisms meet with other forms of fatal biological antagonism.

Curiously the Old Testament, which forbids the eating of blood and of animal fat, also specially condemns the eating of the hare, swine, mussels and other shell fish as unclean animals. "Whatsoever hath no fins nor scales in the waters that shall be an abomination unto you."

In the light of what has already been said about survival and pathogenesis, the following passages taken from Prof. H. A. Strong's article on "The Jews through Roman Spectacles" in the *Hibbert Journal* (Jan., 1915), will now be seen to throw not a little fresh light on the problems of the downfall of some nations and the persistence of others:—

The constant expressions of surprise and disgust at the abstinence of the Jews from swine's flesh may strike us as remarkable. But the existence of this prejudice is evident and constantly referred to.

Caligula received an embassy from the Jews and thought it a smart sally to question them solemnly to disclose the very important reason why they would not eat pork.

Tacitus knows the reason for the abstinence of Oriental nations from the flesh of the animal which served them as scavenger; he says, they were afraid of contracting leprosy, which at one time afflicted them to a fearful degree.

But it so happened that the favourite animal food of the Roman was pork. The very term "*caro suilla*" a diminutive form, has been noticed as showing the weakness of the Romans for their national dish.

The abstinence from their national dish must have struck the Roman nationalists much as an insult paid to "the roast beef of Old England" would have done to an old-fashioned person who believed that patriotism and beef were in some way connected.

Does it not seem tragic, in the face of the facts of history, that the Romans should have been so indifferent as to the creeds and the spirit underlying the dogmas of foreign nations? Surely had it been otherwise, and had they seen the tendency of the worship of even a tribal godhead to a general acceptance of monotheism such as that adopted by their own philosophers, aversion might have been replaced by sympathy, oceans of blood might have been spared, and the course of religious history completely changed. As it was, they stood by coldly and regarded Judæa expiating by political nullity and dispersion the spiritual intensity which imposed her faiths, in some form or other, upon civilised man.

I would only add the comment that indifference and callousness* as here exposed go before inhumanity and groundless aversion (blind race-hatred and antagonism!) as surely as pride goes before a fall. Huxley said of the early Christians

* There is an Italian proverb which seems reminiscent of the lower spirit of Roman philosophy, as it is also, indeed, characteristic of much "philosophic" spirit distilled out of our own civilisation:

"Morto io, morto ognun, ed il porco."

that the mob hated them as it now hates the Jews in Eastern Europe, because they were more frugal, more industrious, and lived better lives than their neighbours.

Evidently the study of history without physiology is as fallacious as that of physiology without (its) history. Of the Roman legionnaires, at any rate, it must be said that they relied for their stamina mainly on *frumentum* (*frummety* or *firmitry* as the country people call it), much the same as the Scotch used to rely on oatmeal, the Irish on potatoes, the Easterns on rice, the Manchurians on the soya bean, the Arabs on dates, the Kaffirs on mealies.

If over-cultivated plants, such as strawberries and asparagus (which are "forced" and over-manured [poisoned] and therefore reduced in symbiogenetic capacity) can cause obvious morbid symptoms, how far more risky must it be to ingest animal food many degrees further removed from all ties of biological reciprocity than is even such plant-food? That the injurious effects of in-feeding are not so acute in their symptoms as those of the anaphylactic shock has its reason, as we have seen, in that they are in part remedied by the beneficence of the digestive process and in part also converted pathogenetically.

"Probably all idiosyncrasies depend upon anaphylaxis," *i.e.*, as I would say, all reactions coming under this head so far from being mysterious are in reality due to a long-standing poisoning of the body.

It is when we come to "chronic anaphylaxis" that we find permanent injuries caused by poisonings and mutilations becoming very apparent:—

The essential character of the anaphylactic reaction is its rapid disappearance. One of two things happens: either the animal dies in one or two hours at the most, or it definitely survives. At least this is what seems to occur in guinea-pigs and rabbits when the *exciting* injection is made with a slightly toxic and almost harmless substance, like an heterogeneous serum. But, in dogs treated with toxins in second injection, although the second injection be a dose well below the fatal

dose, the animal recovers from the anaphylactic shock, but it dies ten, twenty-four, or forty-eight hours afterwards. Such chronic anaphylaxis is not absolutely peculiar to the dog; for rabbits, at the end of several successive injections of toxins or even of serum, at length die of cachexia.

Comment almost seems superfluous. The animal recovers from the anaphylactic shock but dies of the poison. There is an end of it. To some the recovery may appear as too dearly purchased. Elimination of poisoned material is frequently associated with death, and we are thus strikingly reminded of those frequent instances of nemesis of reproduction, as in parasitism, where the mother's life is frequently the price of parturition, *i.e.*, elimination. Reproduction is in such cases a sort of elimination of what has become an unendurable burden on the parent, and we know that in extreme cases the general morbidity of the species is such that the young actually drain the parent to death. The embryo in the latter cases shows pathological transmission, and, such is the nemesis of biological evil upon a species, that the bringing forth of this offspring, like the elimination of a rank anaphylactising poison, proves costly and precarious and frequently fatal.

Having called for the tune—"ein garstig Lied," as Goëthe would say—a parasitic species must thus in the end pay the piper.

In order to explain this slow death of anaphylactised animals, it must not be supposed that the anaphylactic poison, apotoxin, persists throughout the tissues; for most frequently, in dogs at least, the period of recovery has commenced, showing clearly that in those animals which ought to die slowly, as well as in those which ought to recover, apotoxin has disappeared. The phenomena succeed each other in this order. Firstly, there is the anaphylactic shock, which is violent and leaves the animal for half an hour or an hour in a state of impending death. But, except in very rare instances, death does not follow immediately, and evidences of recovery are apparent. The dog gets up, walks about, seems almost cured, although diarrhœa and tenesmus continue. In spite of this apparent recovery, it becomes very weak some hours later; it cannot rise from the ground; it has profuse intestinal hæmorrhages, complete inertia, insensibility, and an abnormally low temperature.

In all probability it dies of lesions, visible or invisible, produced by the apotoxic poison. *Sublata causa non tollitur effectus*. The injuries

to the nerve-cells have been so serious that they cannot return to their normal state, although the poison affecting them has disappeared.

And thus we get a good illustration of what I mean by the slow (biological) death of in-feeders; for, as I have already pointed out in previous volumes, what happens thus in individuals also happens on a grand scale, though more gradually, in Nature, and leads to the extinction of species. The substance of nerve-cells represents some of the highest physiological assets, *i.e.*, investments of biological capital, that exist, and when this valuable substance is pathogenetically affected by the advent of debasing, *i.e.*, deleterious substances, a general retrogression ensues which may end in extinction of a species. Occasional attempts at recovery there may well be, but they must be increasingly frustrated by a continuance or intensive increase of the same morbid conditions which made a recovery necessary.

Certain foods like milk and eggs which inevitably induce the anaphylactic state after intravenous injection, never, or hardly ever, induce it by alimentary ingestion.

Let well alone, then, as regards "intravenous" injection. But let us also be sparing in our reliance upon the digestive powers which frequently cannot bear great quantities of "rich" fare, and are thus obliged to give up the protection they have so long and so faithfully afforded. Let us take to heart Cicero's admonition:—

Non intelligunt homines, quam magnum vectigal sit parsimonia.

We are further told:—

Ed. Lesné and L. Dreyfus tried to discover if anaphylaxis could be obtained by direct injection into the portal vein, and gave interesting proof that such an injection is equivalent to injection into any vein whatsoever for the purpose of producing the anaphylactic state.

It follows that if ingestion does not induce the anaphylactic state it is not because the hepatic and intestinal glands and lymphoid tissues have altered the albumin, but solely because changes in the materials introduced through the mouth have taken place in the intestinal tract during gastric and intestinal digestion which render them harmless. And as a matter of fact Ed. Lesné and L. Dreyfus showed that the

injection of white of egg into the stomach or small intestine of a rabbit, or of actino-congestine into the stomach or small intestine of the dog, does not result in anaphylaxis; while, on the contrary, anaphylaxis does result when the first injection is made into the large intestine.

Clearly this indicates that the true reliance of an animal must be on the integrity of its alimentary functions and of its intestinal tract and its power of self-protection by their means.

“Normal digestion entails neither intoxication nor anaphylaxis.” Precisely. It entails instead sobriety and industry, *i.e.*, biological integrity.

As digestion varies, both in its duration and in the formation of various products, in different species and different individuals, so the ingestion of similar albuminoids may lead to very different results according to the species and the individuals taking them.

This is only what might be expected. The following experiment by Prof. Richet shows that the intensity of the morbid symptoms increases with the intensity of the in-feeding. Of nine dogs

three were fed on raw horse-flesh, three on milk, and three on eggs. At the end of forty days I tried to find out if they were anaphylactised to horse-flesh, milk, and eggs respectively. The special feeding was suspended during the last thirty days in the case of one dog in each series in order to eliminate the possibility of anti-anaphylaxis. The three dogs fed on milk and injected with milk as an *exciting* injection presented no symptom. One of the three dogs fed on egg albumen firstly and later injected with it had transient and mild symptoms of pruritus. Of the three dogs fed on horse-flesh and later injected with muscle serum from horse-flesh, one presented very distinct symptoms of anaphylaxis—great fatigue, with prostration and inability to walk.

This shows that egg albumen (in excess) is worse than milk (in excess), and horse-flesh worse than either, and this is what in my view might be expected, since in milk (a “love-food”) no life is sacrificed; in eggs (also “love-food”) incipient life is sacrificed, and in the flesh diet the predaceous quality of the food is obvious.

Prof. Richet asks: “Is it not the inevitable conclusion to be drawn from these experiments that anaphylaxis *sometimes* does develop as a result of alimentary ingestion?”

Our answer, of course, is decidedly in the affirmative, but we have now adduced a precise cause of the trouble, which is more than Prof. Richet has so far been able to do. He thinks indeed that "In the present state of science it is difficult to speak with certainty of any hypothesis."

"A true intoxication, characterised by fever, urticaria, œdema, rheumatoid pains, diarrhœa, vomiting, and the syncopal state, is brought on in some predisposed people especially by fish, molluscs, and crustacea."

Surely, then, this indicates that prevention is better than cure; better far, "in the present state of science," than reliance upon anti-anaphylaxis or upon "anti-sensibilising!"

Why should man embark on such digestive adventures as the devouring of molluscs and crustacea when he can grow an abundance of wholesome plant substance?

"Flowers, and then fruit

Man's nourishment, by gradual scale sublim'd."

It is again highly significant and corroborative of my remarks concerning "love-foods" that—

"Alimentary anaphylaxis has never yet been observed as the result of eating fruit (with the exception of strawberries) or vegetables."

The true anti-anaphylaxis therefore consists in a reliance upon "love-foods"—rich in vitamines and in therapeutic and bio-economic values generally.

Thus even amongst vegetables we have the potato, known to be rich in vitamines, now rapidly coming to the front because of the curative value of raw potato juice (*extractum solani liquidum*!). This juice is said to contain large quantities of potash salts. What need have we then of albumins and albuminoids or of heterogeneous sera, which have no reciprocal biological affinity whatever in our physiological economy!

It is claimed that the application of the preparations of raw potato have a rapidly curative action in various common ailments of the

rheumatic kind, including lumbago, mild joint rheumatism, and synovitis; the latter is the common condition of swelling and effusion (water) which occurs round joints and ligaments that have been bruised or sprained. Remarkable results are reported in the cure of these conditions from the use of hot fomentations or poultices made with potato juice, as well as of cold plasters made from the same substance. It is notable that amongst the successes recorded is a case that was treated at St. George's Hospital under a well-known surgeon. In this example the patient, who had been suffering from water on the knee for some five weeks, was cured in less than a fortnight. For lumbago and rheumatism it is recommended that potato juice ointment should be rubbed well in the painful parts, whilst the treatment may further be aided by the special plasters. For severe bruises and sprains it is advised that the hot poultices referred to above should be first resorted to, when it may be expected that the pain will quickly be relieved, and the swelling go down. The treatment has also apparently some application in gout, although its chief advocate does not claim it as a direct cure for this malady. In gout it would appear that potato juice applied in the right manner will quickly relieve pain and swelling, although it may not be able to relieve the general constitutional symptoms. In the article referred to seven cases of acute gout are recorded in which the remedy was applied with success.—*Daily Telegraph*, 2/5/14.

It is also remarkable in this connection that the Bedouin and other tribes of the desert who keep a sound vitality on a frugal diet of dates, figs, semolina and olive oil, seem impervious to pain, and regard the use of an anæsthetic with contempt.

Anæsthetics, as we have seen, are calculated to suppress the natural and wholesome eliminative efforts of the body; if, therefore, a frugal diet—free from in-feeding—renders their use unnecessary, such a diet must not only be superior in preventing disease, but it must be an additional safeguard of an undiminished vitality—a prevention against pathogenesis.

Very important admissions supporting my general thesis concerning the cause and the general course of disease occur in the chapter on "General Anaphylaxis."

Apparently there is some secondary process, peculiar to anaphylactised organisms and entirely absent in non-anaphylactised organisms, which only develops in anaphylactised animals after a long delay, as if chemical reactions took place within them more slowly and were in any case of a different nature from those which occur in non-anaphylactised animals.

The phenomena of general anaphylaxis, concerning which we know little as yet, must be studied thoroughly. Up to the present we have been concerned only with specific anaphylaxis. But *general* anaphylaxis, that is the increase of sensitivity—be it ever so light—to *all* poisons as the result of the injection of a single antigen, will possess very great interest and will carry from a practical as well as from a doctrinal point of view, important consequences.

In other words, again, the organism is “generally” weakened and impoverished by poison. Its symbiotic powers are diminished and the pathogenetic changes that have become necessary result in an inhibition of other vital chemical reactions. This it is precisely which in the long run leads to a loss of vital biological correspondences and, hence, to retrogression or “degeneration” (“Entartung”), and the fundamental cause of it very generally was metabolic transgression, *i.e.*, in-feeding.

In his concluding chapter, Prof. Richet makes another attempt to rise above technical and local considerations into the sphere of biological interpretation. Summarising his results, he says:—

The fundamental feature of anaphylaxis is the modification of the cells of an organism by the injection of a dissimilar albuminoid substance, so that they seem to react with greater intensity on the repetition of the injection.

Our own conclusion is that such an injection is injurious: (a) because it is a mutilation; (b) because it introduces biologically inadequate or antagonistic material which is bound to turn to poison; (c) because it avoids and sets at nought the protective action of the digestive juices; (d) because it diminishes the organism’s resisting and eliminative powers; and (e) because it generally and bio-economically tends to impoverish the organism.

We have preferred the term pathogenesis to anaphylaxis, and we have observed that the phenomena of anaphylaxis throughout come under the same head as those more gradual pathogenetic phenomena induced by perpetual in-feeding, which we found to be abhorred by Nature, because they run

counter to domestic and biological symbiosis. The fact of a "greater intensity on the repetition of the injection," although apparently so puzzling as to seem almost miraculous to the orthodox biologist, can now be seen to be a mere detail connected with the means of resistance, of defence, and of pathogenesis at the disposal of the organism. The chief element remains the introduction of a foreign substance which is not required, but, on the contrary, constitutes a serious impediment and menace to normal life.

The organism exists first of all for work. It cannot well afford to give all its forces to the speedy extrusion of intruders. It neutralises them, getting ready in the meantime for sterner measures in case of recurrence of similar necessities. A second injection provides the opportunity, as also indeed an urgent call for a supreme effort to cope with the poison. The success of this effort depends on the symbiotic power of the organism. Where this is small, or has already been too seriously impaired, the defensive symbiotic "élan" proves a failure or cannot even be undertaken.

Prof. Richet thinks that we must attribute to the living cell an extraordinarily delicate and complex chemistry, which chemistry, according to him, does all that is needed to produce the various phenomena of anaphylaxis. He entirely overlooks the symbiotic connections of the "living cell" and what they entail in mutual force. He makes, however, a very apposite suggestion which may be read to imply that differentiation of individuals (and, hence, of species) is in accordance with food:—

Just as we have a *psychic* personality by which each is himself and not another; so we have a *humoral* personality which also makes each different from another: this latter personality is due absolutely to the multiple ingestions and intoxications which have altered each of us by leaving indelible effects.

Tal persona, tal pasta!

A German proverb says that a man is what he eats. That the various "multiple ingestions and intoxications" can and

do indeed alter each of us according to the compatibilities of the case, and leave "indelible effects," is to me a matter of observation extending over more than twenty years.

It is clear that the frequent ingestion of flesh meat exerts undesirable effects upon another animal's economy, the cumulative effects of which its own vitality is eventually unable to neutralise; and therein precisely we may see an explanation of the aforesaid biological antagonism between the blood and the serum of different animals—which antagonism we must now consider as a prominent fact in Nature.

Forces there are, of course, locked up in all such substances, but they are not adequate because they do not stimulate as "love-foods" do in the direction of symbiogenesis, but of pathogenesis.

We have seen, from the study of symbiosis, how Butler is justified in speaking of eating as a mode of love, but such love should be characterised by a high degree of symbiotic reciprocity which cannot be said to exist between the blood and flesh of kindred animals. The latter, on the contrary, must be said to repel each other, chiefly for the reason that their union is abhorred by Nature, *i.e.*, runs counter to the mightiest of all evolutionary laws, that, namely, of symbiogenesis.

In some cases, as we have seen, the blood of one species destroys that of another, and this has to do with specific self-preservation, *i.e.*, with the preservation of indispensable bio-economic diversification. The blood of one species of animal injected into the veins of another is an undesirable alien element which is poisonous because it is utterly lacking in possibilities of reciprocity, and because assimilation of one by the other is biologically undesirable. Such a method is not the way to raise the "tone," but, on the contrary, tends to lower it. It is similar to perpetual in-feeding which we must now view as a kind of close in-breeding—seeing that eating is indeed a kind of love—though toxic and pathogenetic effects are here as slow as they are also far-reaching.

Perpetual in-feeding yields forces which gradually achieve an undue dominance of alien elements, which are never thoroughly or desirably assimilable or to any degree reciprocal or useful, and therefore landing the species finally in degeneration or extinction. Such "incest" once begun, like other forms of depravity, is apt to spread and gain momentum until it ends in destruction.

In se semper armatus Furor, as Seneca has it.

Fortunately for all of us—although we will admit that "the domain of anaphylaxis is immense"—ancestral alimentary ingestions of a normal (cross-feeding) order have far outweighed incestuous "intoxications." Otherwise pathogenesis would have prevailed over symbiogenesis, and no amount of anti-anaphylactics could have averted our doom.

The injection of albuminoids, according to Prof. Richet, either increases the vulnerability of the living cell or it diminishes it, or it exerts both these contrary functions, according to the individual. But we must count the total cost, when it will be seen that the diminution of vulnerability in some cases is more apparent than real, and that the main injury is the positive reduction or relative handicapping of the general symbiotic powers of the organism. That the organism is never the same again after an injection, and has hence also biologically deteriorated; that it has thus been permanently modified according to pathogenesis rather than symbiogenesis, are eloquent facts. That the injection of certain mainly animal albuminoids is so widely resented by the animal physiology speaks volumes for their general unsuitability as foods, and indicates at the same time that every suppression of the protective reaction of the body amounts to a suppression of a valuable safeguard of racial purity.

Prof. Richet hopes that some day, "when we shall have thoroughly studied *general* physiology and the physiology of *species*," we shall understand more about the idiosyncrasies exhibited by anaphylactic phenomena, and that then the

explanation of many morbid phenomena—of the uncertain facts of pathology—will speedily follow.

This study, however, I submit, resolves itself mainly into one of domestic and biological symbiosis in the widest sense, and especially of nutrition as the means to these, and it is this study I have tried to commence.

Somewhat forestalling this study, Prof. Richet throws out the following general biological considerations, which, he says, have not been presented, and which, as it seems to him, it is necessary to place before the learned for reflection:—

It may be asked how anaphylaxis can be reconciled with the law of defence of organisms; for, after all, defence is diminished when sensitivity to intoxication is increased.

Now, although it can only be an hypothesis, it may be allowed that the defence of the organism is not merely a defence of individuals but also a defence of the species. It is not merely a question of each individual maintaining its existence, it is also necessary that the individuals shall remain like to each other. If heterogeneous substances could penetrate the organism with impunity and modify its fundamental chemical properties, entering into the protoplasm and altering its nature, then all would be over with the somatic constitution, the fruit of slow and ancestral acquisition, of each kind of animal. All progress acquired by selection and heredity would be lost and we should be at the mercy of chance, of accidents, and the occurrences of each day which would be capable of modifying, in accordance with complicated formulæ, the actual *optimum* state in which we are. *Every being must be stable* and it is to maintain this stability that the individual reacts with such energy to the chemical changes which affect it.

With this passage I have no fault to find, but, on the contrary, hasten to give full assent, glad to see that such wider, practically bio-economic, considerations commend themselves increasingly to leading men in the various fields of Biology. It is all a question of maintaining stability in the interest of indispensable bio-economic (reciprocal or symbiotic) specialisation. This is why every being “must be” stable, and this is also why it must be whole and healthy and on its defence against any interference with its integrity.

CHAPTER VI.

ORTHOGENESIS.

Ipsum enim bonum non est opinionibus, sed natura.—CICERO.

Nunquam vera species ab utilitate dividitur.—QUINTILIAN.

Nature does not do so very ill herself, and in Nietzsche's estimation, is not to be set down as immoral because she is without pity for the degenerate.—W. MACKINTIRE SALTER.

There is but one right, and the possibilities of wrong are infinite.—
T. H. HUXLEY.

Peut-on vraiment continuer à soutenir que la différenciation en soi et par soi, en tout et pour tout, marque un progrès?

Ce sont les forces de l'intelligence, activités de synthèse, de co-ordination, d'alliance qui sont, pour l'évolution humaine, les mères dont parle Goethe, génératrices inépuisables des formes.—BOUGLÉ.

The theory of orthogenesis, or progressive variation along a definite line, is associated with the name of Prof. G. H. Th. Eimer, and more particularly with his volume on "Organic Evolution." His views are supposed to be Lamarckian and Goëthian.

According to Prof. W. Bateson, orthogenesis at the present day commends itself to some naturalists, although he thinks that evidence in support of the theory is totally lacking.

By crediting an organism with an innate tendency towards certain lines of variation, the theory of orthogenesis is supposed to solve the problem of the beginning of variations before Natural Selection is able to take hold of them (that is, I suppose, the pre-determination of variations by nutritional, *i.e.*, bio-economic factors, which pre-determination obviously need not be set down as mere accident). But, say the critics, it is still left an open question why the organism varies in definite directions. My explanation is that it does so because

every species is dominated by either symbiogenesis or pathogenesis. At any rate, I hold that there is no truly progressive orthogenesis without symbiogenesis, and that I am justified therein the following consideration of Prof. Eimer's book will show.

The translator of this work is Mr. J. T. Cunningham, who deservedly holds a high rank amongst biologists, although, owing to his opposition to fashionable creeds, he is not in high favour with the powers that be in Biology.

In his preface, Mr. Cunningham points out the importance of the study of the causes of variation in particular of functional activity and external conditions. By such study he was "led to believe that a deeper insight into the phenomena of evolution would ultimately be obtained by pursuing the line of inquiry suggested by Lamarck, than by continually searching for new instances of adaptation to be explained by the Darwinian formula"; and, he continues: "When I saw that many of the ablest British biologists accepted Weismann's dogma that acquired characters are not inherited, it seemed to me that they were abandoning the richest vein of knowledge under a mistaken guide."

I concur with Mr. Cunningham that: "To some extent the controversy concerning the inheritance of acquired characters is due to an ambiguity of language."

On purely logical grounds alone, I hold that Samuel Butler has already settled this controversy in a sense unfavourable to Weismann's contention. Quite apart from Butler, and indeed before I knew his writings on the subject, I had come to the same conclusions, particularly on finding that Weismann's inferences concerning the complete isolation of the sexual elements were based on facts taken from abnormal life, *i.e.*, on premature developments due to morbidity.

A number of sincere biologists would be only too ready to believe in the inheritance of "acquired characters"—essential as transmission is to a rational view of evolution—if, as they say, they could but see evidence thereof. Thus Prof.

Poulton tells us that Lamarckian evolution, Spencerian evolution, appeals to the mind of man far more strongly than Darwinian evolution. Everyone of us, he says, would have made the world according to Lamarck. "We would have made evolution by use and disuse of parts and not by Natural Selection."

It should be borne in mind, however, as I have pointed out in *Evolution by Co-operation*, that there is not only use and disuse in the world, but also an abundance of *misuse*, and hence there has to be a corresponding amount of protection against misuse, which of course must frequently express itself as so much intolerance of acquisitions. We cannot expect Nature to be very anxious to bring about the inheritance of anything that is connected with misuse; and if unwittingly and for want of a proper analysis we are most generally drawn to the study of the abnormal (which is generally as conspicuous as it is also abundant), we must expect to meet with difficulties of heredity and indeed difficulties of all sorts.

So long as the chief function of an organism and the chief influence of the biological environment—viz., the bio-economic—are overlooked, and so long as the organism is studied locally and singly without reference to bio-economic developments, we cannot expect to obtain any but incongruous results. Superficial consideration of a few such results has led to the belief that no "acquired" characters can be inherited.

But though the (abundant) chaff is not wanted, the rare grains are, and the treasures of the grains, though inconspicuous, are well guarded, cherished, and increased in Nature by symbiogenetic means. Biological correspondences, as we have seen, are a part of such heritable acquisitions (capital) quite as much as are structural additions. Indeed, as we have found, such heritable biological correspondences constitute in great part the wealth of a species, and, hence, the mechanism of the inheritance of acquisitions must be looked for among these correspondences and their results, quite

as much as in the individual "characters" and powers of the organism itself; that is to say, that some of the factors making for such inheritance are in the symbiotic environment and cannot operate unless the symbiotic co-operation is fully carried out, even though some of the factors, and perhaps the most prominent, may be found in the organism itself. Such co-operation is parallel to that of the sexes in simple reproduction.

If the main method of evolution—symbiogenesis as supported by cross-feeding—has so long escaped the ken of our naturalists, we cannot be surprised to find that similarly the manner in which essential acquisitions come and go, and meet with biological approval or otherwise, has escaped them, or only been occasionally glimpsed or partially realised. It is always of prime importance in evolution to acquire useful biological correspondences and to transmit only that which is in accordance with desirable adaptation. Other acquisitions are but secondary, and, as we have seen, frequently of a pathogenetic order. The latter, naturally enough, involve endless conflicts in which, as we have seen, digestive, genetic, and symbiogenetic momenta are primarily concerned.

Acquisitions related to a pathogenetic order, therefore, are fought against by Nature so long as possible; but it does not follow that the inheritance of all acquired characters is therefore abhorred, or that all "acquired" characters are non-inheritable. It only follows that "characters" are heritable in different degrees, according to the compatibilities and possibilities of response in each case.

Acquisitions of the normal order are inherited in due time, and if their effects eventually become manifest as though variation in a particular species proceeded by an orthogenetic principle, this is because all normal and desirable acquisitions are in accordance with a grand progressive bio-economic principle, viz., with symbiogenesis, *i.e.*, because they have met with genuine biological approval.

Both Mr. Cunningham and Prof. Eimer are ever emphatic in pointing out that physiological change precedes morphological. Thus the former tells us:—

There is a climbing kangaroo in Papua which shows so little adaptation of structure to the climbing habit, that no naturalist would believe from the mere study of its body that it lived in trees. But as a matter of fact it does live entirely in trees.

What Mr. Cunningham here wishes to convey, of course, is that this kangaroo has not yet had time to adapt its structure to the climbing habit, but will presently do so, and that we have here, therefore, an indication of how habit precedes structure, and how orthogenesis is explainable on physiological grounds. In reality, however, orthogenesis is here to be explained by symbiogenesis. On my symbiogenetic view of evolution, moreover, there is nothing to necessitate the belief that *every* habit formed (even so useful a one as climbing) must needs cause "adaptation" of the whole structure to a conspicuous degree. The better the habit the less need it lead to an extreme determination of the organism in accordance with the particular habit, and vice versâ in the case of bad habits.

Now, tree-climbing in this instance is essentially connected with arboreal life and with cross-feeding. The kangaroo, therefore, may be said to be on the path of symbiogenesis, and capable of relying on symbiogenetic momenta generally, and not needing to specialise in extreme determination, *i.e.*, in dependence on a particular prey, as, for instance, did the sabre-toothed tiger, whose teeth-formation rendered it impossible for it to prey on any other animal when it had destroyed the whole species of giant armadillo.

The kangaroo, because of its physiologically sound, *i.e.*, symbiogenetic feeding-habits, could afford to be arboreal without a highly specialised adaptation for tree climbing, which might have rendered subsequent terrestrial adaptation difficult or impossible. It presents the example of an animal wisely preservative of symbiotics, showing a remarkable "survival of

behaviour," *i.e.*, as I would also call it, a preservation of cosmic loyalty.

It is precisely from such a symbiogenetically loyal, and therefore well-balanced, and not over-specialised animal as this Marsupial, that, in my opinion, long lines of ascending species—possibly man himself—may well have sprung. We have seen that organisms in order to become progenitors of permanent races, must make their adaptations congruous with the general symbiogenetic advance of the world, and that this advance gives the chief direction to their evolutionary process. Adaptations and specialisations, *per se*, we found to be not enough, and we have seen further, that they may be actually injurious (in a permanent sense) when attended by loss of vital symbiogenetic correspondence.

Nature works with long, *i.e.*, with symbiogenetic roots, and an organism which is oblivious of these roots and attempts to live by short cuts, will eventually find itself deprived of its main support. Wherever great and permanent good results are to be achieved, therefore, loyalty to great bio-moral principles is required, and this does not permit of over-adaptation in any particular direction, but requires restraint and harmonious adaptation. That a progressive species does not live for itself merely is expressed by its harmonious, *i.e.*, cosmic adaptation and by its well-balanced structure.

It is significant that, according to Albertina Carlsson (*Knowledge*, June, 1914), one tree-kangaroo, *Dendrolagus dorianus*, is distinguished from the typical members of the family (*Macropodidae*) in not showing the usually conspicuous disproportion between fore limbs and hind limbs. It sometimes walks on the ground with both hands down, or with only one; it sometimes climbs with its hands gripping the branches.

This example seems again to indicate that physiological change precedes morphological, and, we may add, that if this change happens to be a symbiogenetic change it does more; it predetermines subsequent variation and subsequent evolution

in a favourable sense, not only in a definite but also in a biologically desirable manner.

Prof. Eimer objects to Darwin setting up utility as the only ruler in the organic kingdom.

By the unconditional assumption of this supremacy it was quite overlooked that utility is a purely relative conception, and that therefore it cannot possibly be the fundamental principle of the forms of the organic world.

If in Darwin's assertion that every "character" occurring in an organism must either be now useful "to it," or must once have been useful, we substitute the word "bio-economically" for "to it," Prof. Eimer's objection at once falls to the ground, and we arrive at a wide standard of usefulness, with the aid of which we can, as I believe I have shown to a certain extent, complement Darwin's quasi-economic non-orthogenetic and likewise Prof. Eimer's non-economic orthogenetic theory.

Prof. Eimer's method, similar to that of Prof. Keeble, consists in giving himself unreservedly for once to the study of a single living being, in order to penetrate into its nature as deeply as possible.

The single chosen object soon tells him more than all other animals or plants together which he has observed more superficially.

I was able to demonstrate that variation everywhere takes place in quite definite directions which are few in number, and I was able on the basis of my observations to put forward the view that the causes which lead to the formation of new characters in organisms, and in the last result to their evolution, consist essentially in the chemico-physiological interaction between the material composition of the body and external influences.

Still, such method—though it has its use—would seem to be open to Prof. Eimer's own criticism of other methods that:

Anything that is not teased with the needle, or cut with the microtome or examined with the microscope is scarcely noticed at the present day, except by those who are exclusively systematists—even in questions connected with the evolution theory.

We have seen that chemico-physiological interaction itself needs to be studied in the light of bio-economic interaction, and that the explanation of "definiteness" thus becomes more

rational, more comprehensive and more valid than one which is satisfied with purely chemico-physiological factors. By entertaining a Goëthian idea of "cosmic" adaptation, however, it may be said that Prof. Eimer has obtained a kind of intuitive guiding principle as regards evolution by which to measure definite variations.

When he states, moreover, that "sexual separation has developed on the basis of the advantage of division of labour, and the prevention of in-and-in-breeding," we see that he is willing to recognise some kind of broad principle of utility. That the true and determining utility here concerned, however, is a bio-economic utility is worth emphasising once more.

Prof. Eimer recognises that an "adaptation" may be "necessary or useful to other creatures or to the generality of things," and he would distinguish the latter as "general" or "cosmic" adaptation from "special" adaptation.

Individuals during their life also adapt themselves to the external world—consider only the variety of the experience which individual animals during life, according to their surroundings and their intelligence, meet with and benefit by, or the special strength of body or any other useful qualities which they acquire in consequence of the external demands upon them.

Amongst six "particular causes which determine the differences in the direction of evolution, and which also contribute to bring about the division into species," he mentions indeed "the functional activity of the organism in relation to the external world, which directly strengthens characters in process of development by the exercise of them," but he is still a long way from realising how such "cosmic" adaptation is bio-economic in character and is so among the most important of all determining causes.

Speaking of sexual mixing as a determining cause of evolution, he tells us that:—

The sperm-nucleus and the egg-nucleus must in their physio-chemical properties form with perfect exactness the complements of one another, if through their union a new organism is to be produced, which shows how high the requirements are of reciprocal

differentiation generally, and how delicate the balance required between a due pair of opposites in Nature. Without the fundamental necessity of adaptation according to cosmic (bio-economic) needs, *i.e.*, without symbiogenesis, the high duties required by reciprocal differentiation could not be discharged, nor could orthogenesis unaided by symbiogenesis keep the organism for long on the path of progressive reciprocal differentiation. We have in the extreme sexual dimorphism of parasites also a kind of orthogenesis, although in the absence of symbiogenesis it is, as I have shown, unbalanced and pathogenetic in character, and it is difficult to suppose that in such cases sperm-nucleus and egg-nucleus are really perfect complements of one another. Frequently the sperm appears as nothing more than the merest spark to set the germ going and moving along further down the inclined plane of pathogenesis, towards extinction; *i.e.*, the movement is definite in direction but retrogressive.

The correlative alteration of the sexual products leads to the consideration of a fact which seems to me to cry loudly against Weissmann's assumption that those products remain essentially unaffected by the condition of the body from time to time. I refer to the great correlative influence which conversely the condition of the sexual products, namely their maturity (puberty) and their artificial removal (castration) as well as the extinction of their powers in old age, has upon the condition of the whole body. This relation is so well known that it is unnecessary for me here to give any proof of it. But it is at the same time one of the most striking examples of correlation, and certainly affords most valuable support to my conclusion that changes in the characters of the body appearing suddenly through correlative growth may lead to the formation of new species without the assistance of selection.

We have seen that correlation as a part of symbiogenesis is a great factor in evolution, whilst there is a vast amount of correlation associated with pathological factors making for pathogenesis and ultimate extinction. Prof. Eimer thinks that through correlation new species can arise without the aid of selection:—

As soon as something or other in the original state, in the original arrangement of the parts of the organism, is changed, other parts also are set in motion, all arranges itself into a new whole, becomes—or

forms—a new species, just as in a kaleidoscope, as soon as on turning it one particle falls, the others also are disturbed and arrange themselves in a new figure—as it were recrystallise.

We have just seen how this works out in pathogenesis, and how inversely very gradual synthetic processes of correlated growth and correlated inheritance mark evolution by symbiogenesis.

The abundance of the species which have been formed by degeneration, by retrogression, is known to every zoologist. It is self-evident that their origin is to be traced to the action of external conditions, that they have been produced by acquired and inherited changes of growth depending on these conditions.

Thus again we see in the case of a zoologist as we saw previously in the case of a botanist and of a pathologist, that, in the absence of bio-economic explanations, the mere fact of the abundance of abnormality becomes so bewildering that the possibility of self-pauperisation is never broached, even by the most philosophically inclined amongst them.

Yet we are loath to admit the excuse of external conditions in a human degenerate! Though it is justly pleaded that more frequently than not his is a case of heredity—which should indeed, if proved, be at least an extenuating circumstance—yet his degeneracy is frequently connected with previous transgressions within the particular stock, *i.e.*, the responsibility rests with a kind of specific self-pauperisation. In the Biblical terms, “I will visit upon you the sins of your fathers unto the third and fourth generation.” These words, according to Prof. Eimer, “have a profound significance, and the manner of life, the lot in life, and the selection of the ascendants in great measure determines the fate in the life of coming generations.”

The importance of the distribution of blood in the body as a physiological factor determining growth in a definite direction, is also mentioned. We have seen how this distribution is determined by nutrition, *i.e.*, by factors of biological symbiosis which in their powerful reaction determine the conditions of domestic symbiosis.

In his "explanation of death," the same writer tells us: "Reproduction is unending growth." But, as we have seen, it is also (normally) more than growth. It is higher-production through elimination, rejuvenescence and symbiogenesis; *i.e.*, providing the scope for increasing symbiotic "élan," the opportunity for an ever-increasing production of biological values, such, for instance, as "love-foods."

What experiments and a change of external conditions frequently fail to do is apparent from the following passage: "In thousands of cases, on the other hand, we are unable by changing the external conditions to bring about any change at all in the organism, even of temporary duration—the animals or plants perish rather than adapt themselves; we succeed by experiments only in killing them very rapidly."

Seeing thus how ineffectual a mere change of external conditions frequently is, we are left wondering where after all the real seat of organismal change really lies, and wherein the desiderata of progressive change really consist.

Prof. Eimer's own conclusion concerning acquired characters stands thus: "Every character which must have been formed through the activity of the organism is an acquired character. All characters, therefore, which have been developed by exertion are acquired, and these characters are inherited from generation to generation."

With this conclusion I have no fault to find, except that I lay chief stress upon bio-economic, *i.e.*, symbiogenetic activity and its results, and that I attribute to such activity the most permanent effects, which Prof. Eimer, however, does not notice.

The eminent Orthogenist notes that luxuriance of nutrition produces definite changes of form so far as various characters and their correlated parts are concerned: "Hunger causes leanness and feebleness, over-feeding fat and laziness" (which latter condition, of course, is primarily a physiological—or pathological—rather than a morphological "character"). "It is another question," he continues, "whether specially

abundant nutrition continued through several thousands of years does not produce constant characters in a species of plant, so that the species could no longer exist if brought again under conditions more unfavourable (?) to nutrition."

My contention, once again, is that specially abundant nutrition over long periods of time *does* precisely produce pathogenetic, precarious and often fatal results, both in animals and in plants, though, it is true, quite definite and in a sense orthogenetic. Such results frequently, as we have seen, make desirable reconversions impossible, and they tend, in Prof. Eimer's own words, to burden the organism with harmful characters.

It is precisely a faulty or abundant nutrition that leads to a faulty distribution of blood, and hence to physiological pauperisation and *misère*.

It is also true, as mooted by the same zoologist, that the time element requires due consideration. Once this element is truly focussed, the value of symbiogenesis is apt to become specially apparent. It is not to be denied that both in-feeding and over-feeding are quite possible for a time. But such modes of feeding are unsound and fallacious from the more permanent racial, biological and cosmic points of view. I have provided plentiful biological and sociological instances in proof thereof in my previous writings, and I feel I cannot insist enough on these important connections.

Prof. Eimer points out quite correctly: "Only by gradually bringing the organism slowly, step by step, during a very long period of time into new conditions—if, moreover, the new conditions harmonised with the direction given to the evolution—could the artificially-produced characters possibly be maintained."

But what about the "direction given to the evolution"? It requires, I maintain, *the recognition of values* and the possession of *a valid biological analysis* to discern on what path of evolution a species is travelling. We have seen it confirmed in the case of anaphylaxis, which is hereditary and

closely related to wrong feeding, how clandestinely a negative and eventually pathogenetic direction may be given to evolution. It follows that we must study the nutritional past of a species and the correlated changes of form and of use-relatedness in the web of life to discern the prevailing direction which the consequent slow and gradual metabolic developments have given to its evolution.

Prof. Eimer tells us that butterflies are known "on whose colouring and markings the food of the caterpillars has great influence."

I have special grounds for the conviction that many new species have arisen through the caterpillars having been at one time or another forced to accommodate themselves to a change of food. In evidence of this is the fact that numerous very slightly differing species of *Vanessa*, e.g., *V. polychloros*, *V. xantho melas*, *V. album*, and *V. urticae*, lay their eggs on different plants. It is natural to infer that in such cases the difference in the quality of the food has been the cause of the origin of different characters.

This bears out in part my thesis as regards the importance of nutrition in evolution, and likewise my proposition that all animal development can be studied duly only if that of the connected flora is simultaneously taken into account, for it is obvious that one part of the hereditary mechanism of these butterflies lies outside their own organisation. The same must be said of some of the observations of Gabriel Koch on the Variation and Formation of Species in Lepidoptera, as instanced by Prof. Eimer.

A change in marking is easily produced by a change in the plants fed upon (the "bear" and other species).

Nocturnal species which live exclusively on conifers have dull colours, usually grey, as for example our pine hawk-moth (*Sphinx pinastri*), or the pine-spinner (*Gastropacha pini*), and several foreign species. This is so invariably true that Koch was able to conclude from the colours of certain species from Sydney and Baltimore that the caterpillars lived upon coniferous plants, and when he suggested that they should be sought on such plants his conclusion was found to be correct.

It is known, Koch says, that when the caterpillars of our German "bears" (*Chelonia* s. *Euprepia caja*) are fed from their hatching to

their metamorphosis with leaves of *Lactuca sativa* or *Atropa belladonna*, not one of the imagines produced resembles the original form; when the insects have been fed on lettuce the white ground-colour of the wings predominates; when fed on deadly nightshade the brown markings of the upper wings often coalesce and the white vanishes; in like manner the blue markings on the lower wings fuse together and displace the orange-yellow ground-colour. To which I may add, that, according to Koch's work, *The Lepidoptera of South-West Germany*, feeding with belladonna and poppies produces dark-coloured imagines. Koch made experiments with similar results on *Chelonia plantaginis* and *Gastropacha pini*. Finally, he refers to experiments with similar results on species of *Militæa* and *Argynnis*, as already known.

Must not, concludes Koch, similar processes occur equally, and even on a larger scale, in the natural life of the countless forms of the class in question? When a great number of individuals perish through an occasional scarcity of their proper food-plant, must not nevertheless considerable numbers survive by contenting themselves with other allied food materials, and so give rise to varieties whose origin we do not dream of, and which therefore we are led to regard as new species?

Speaking more broadly than Prof. Eimer, I would say that it is fluctuations of symbiogenesis that determine evolutionary changes.

We are further told that:—

It is a physiological demand that constant, regular, not excessive use of any organ is absolutely necessary to its maintenance. Indeed, the stimulus to which it responds is undoubtedly the influence to which an organ owes its origin and its gradual evolution.

We have seen that this physiological demand is also pre-eminently a bio-economic and symbiogenetic demand, and that the recognition of this is essential to a real understanding of evolutionary developments.

As regards "Intelligence, Reason, Habit and Instinct," Prof. Eimer has the following remarks:—

I conceive the distinction between intelligence and reason in the following way: Intelligent actions are those which only have in view the momentary and immediate personal interests; reasonable action is that which also considers in relation to its experience and faculties the general interests—fellowmen—and the future, knowing that by so doing personal interests are doubly protected—or which depends on general conclusions. These definitions by no means imply that there are no animals which act according to reason. Indeed, it can be proved by

examples, to those who reflect without prejudice, that animals reason; and that in animals actions founded on reason become automatic and are inherited I have already pointed out in my Freiburg address.

I describe as automatic actions those which, originally performed consciously and voluntarily, in consequence of frequent practice, come to be performed unconsciously and involuntarily. Herein I differ from those who use the term automatic as synonymous with reflex.

I append these statements because they seem to square with the symbiogenetic view of adaptation as here presented. We have seen that organisms normally understand their own business of life, though their understanding may be quite different from what ours would have been, arrived at from the human point of view. There is at least one sense in which man is not the measure of all things. We have indeed seen that organisms perform their part in life so well—and this is what matters most—that they quite efficiently, if unconsciously, fulfil those wider and onerous bio-economic duties on the proper discharge of which all higher evolutionary developments depend.

Nay, there is no reason why they should not excel in their manifold ways of adapting themselves to their environment, which after all is so much simpler than our own, and allows of the whole undistracted attention of the organism being accorded to this one matter of adaptation to a relatively simpler and uniform environment. We are apt to forget that organisms lead the simple life, and that this—just because it does not distract attention from, but rather concentrates it on essentials—has the effect of sharpening the senses, whilst in a highly complex and pampered civilisation other things engage most attention and these vital senses are allowed to lose their acuteness. However puzzling, therefore, the adaptation of many organisms appear, there is no reason to think that it is so inexplicable in its very perfection as it seems to us, but we may explain it as gradually acquired “experience” transmitted and increased from generation to generation.

“Chance never helps the men who nothing do.”

This is true also of organisms. The fact that all strenuous organisms participate in a symbiogenetic union is also important testimony to the essential uniformity of experience, in spite of all differences of degree.

With Prof. Eimer, I would say that the possibility of reliance upon increasing division of labour and the resultant security, *i.e.*, upon correspondences (of domestic and biological symbiosis), has rendered it possible for organisms to depute an increasing share of activities once performed consciously and voluntarily to the realm of the automatic (*i.e.*, the unconscious and involuntary) as soon as the corresponding faculties have taken deep symbiogenetic root in the organism. That there is, normally, a vast amount of such reliance on biological symbiosis, on symbiogenesis and symbiogenetic momenta, makes it all the easier to understand how the automatic mechanism could gradually become perfected and increase in importance, thus leaving the brain at liberty to work in other directions, and to acquire new faculties. We can thus rationally understand all such development as the fruit of work done and as the necessary complement of such work.

Such acquired automatic actions (continues Eimer) can be inherited. Instinct is inherited faculty, especially is inherited habit. Or to state it more accurately, instinct is the power of habitually acting without reflection so as to attain a given object—in such a way as intelligence or even reason might dictate—in response to internal stimuli depending on the condition of the body, and in some cases to external stimuli also.

No other scientific explanation of instinct seems to me possible.

He goes even further in adumbrating the symbiogenetic view thus:—

The view I have given of the nature of mental faculties and of their origin, and particularly this view of the nature of instinct, will appear the more probable the more the reader assimilates and understands the consequences of the idea that the organic world is a connected whole, and that in particular the most nearly related forms are clearly to be regarded as differentiated by division of labour, as organs of a larger organisation.

As regards the much-debated and ever-fascinating case of the Cuckoo, Prof. Eimer states his belief thus:—

That the original progenitors of our cuckoo when they began to lay their eggs in other nests acted by reflection and with design. We have no certain knowledge that the cuckoo does not at the present day lay its eggs in other birds' nests after conscious reflection. We do not know, therefore, how far this action is due to intelligence. That it is not a perfect instinct is shown by the fact above-mentioned, that our cuckoo at times sits on her own eggs and feeds her young; and it is especially noteworthy that it builds no nest for the purpose.

This is, of course, disputed. Brehm ascribes the statement to a confusion of the cuckoo with the goatsucker, but Darwin himself regards it as satisfactorily proved. But if the fact is considered unproved, the other fact that the American cuckoo sometimes incubates its own eggs, sometimes lays them in other birds' nests, and the *a priori* assumption that the instinct of our cuckoo has been gradually developed, imply that there was a time when it still occasionally incubated its own eggs, as conversely the American cuckoo now only occasionally lays its eggs in other nests. Who can prove that reflection did not underlie this difference of action, determining it according to the different conditions? For the cuckoo certainly shows reflection in its choice of nests in which to lay its eggs, and in many other actions. But whether our cuckoo acts at the present day from pure instinct or still by reflection—even assuming the first—it is, I believe, necessary, in order to explain the instinct, to start from the supposition that it has arisen by the inheritance of habit originally intelligent. The conditions of life of the bird enable us to understand easily enough the ultimate causes of the habit.

The cuckoo lives the life of a vagabond. It wanders about restlessly; in the first place, it remains with us only a few months, from April to August; secondly, even in the region where it settles here it has no permanent station, it wanders now in one direction, now in another. This restlessness is caused by its insatiable appetite and sexual desires. It is ever seeking food and mates. Its food consists principally of caterpillars, especially those which, like *Gastropacha pini*, occur only here and there in great abundance. The cuckoo must therefore move about in order to satisfy its need of food. When it has found a swarm of caterpillars it revels in excess, and its sexual requirements are increased.

* Speaking of the long duration of the egg-producing season in the case of the cuckoo, he says:—

It was probably ultimately determined by the irregular habits of life, the irregular, but on the whole extraordinarily abundant consumption of food, and the varying demands of sexual excitement. Thus our domestic hens have been brought by continued high-feeding to lay eggs throughout the greatest part of the year, and to receive the male

throughout the whole of this time. The latter condition must tend to increase the number of eggs laid. In man and many domesticated animals even winter has no effect in diminishing generative activity, as it has in most of our wild animals. It is even possible, although not proved, that the cuckoo continues to lay eggs during the winter of its period of reproduction—during about two months—and so lays as many as twenty to twenty-four eggs (Brehm).

The degenerative evolutionary effects of over-feeding are thus again brought home to us; but it is worth noting, in my view, that the cuckoo is a rank in-feeder, and with this arise important bio-economic implications which cannot by any means be left out of account.

The evolution of the cuckoo proceeds pathogenetically mainly because of its biologically wrong methods of feeding, and I regard its excessive sex-hunger like that of all morbid stocks and of parasites generally, as emanating from the same cause—the same diathesis, the same “ammonisation” of the blood—“Blut-entmischung,” as the late Dr. Lahmann called it—as that which is responsible for “anaphylactic” phenomena, and for costly eliminative processes both physiological and biological.

I have treated of the biological nemesis involved in the case of the cuckoo in previous volumes, and I believe I have to some extent shown in this connection that the Malthusian doctrine of population and that of the struggle for existence require modification in the light of my bio-economic thesis, which insists upon the distinction between normal and abnormal phases of growth and development.

I have been taken to task by some critics for insisting on the parallel of biological ethics with human ethics, but I have not seen any reasons advanced why I should not do so. Prof. Eimer also sees the same fairly obvious parallelism or even fundamental identity of origin, although he fails to recognise the qualitative distinctions that I have drawn. Thus he says:—

There are vagabonds in human society, in the lowest as well as the highest, who lead in all respects a cuckoo's life—our knowledge of

these enables us better to understand the instinct of the cuckoo. Such people trouble themselves no more than the cuckoo about their offspring, but let others look after them, and even leave them at other people's doors, or at the doors of the foundling hospital.

He also thinks that animals, when they founded families or states, must have seen the advantage of several members living together, *i.e.*, the fruitfulness of co-operation. "The bees, for instance, must also have seen that the gathering of stores for the winter was useful to them," a view which is supported, he thinks, by the fact of the high mental endowments—not of an instinctive character—which are displayed by the hymenoptera.

It is obvious that the storage instinct is particularly highly developed in those organisms which rely upon mutual support, *i.e.*, on symbiogenesis, for it is they that work the hardest to purchase the most margin for evolution through accumulation of capital and increasing division of labour. In order to purchase such advance they require not only surpluses for their own use, but also, as I believe to have shown, surpluses for purposes of exchange.

Though the consciousness involved was at best but rudimentary, yet the solution of the biological problem resolved itself from the first into the establishment of equitable bio-economic relations, and the only reliable path to this, as the case of the bee so well proves, was that of cross-feeding.

The bee applies for food to the plant which is itself a storer of energies and of surplus substances, an accumulator of biological capital, and a useful and biologically sound commerce is set up and maintained to their mutual advantage.

Prof. Eimer, in order to emphasise the strength of his position as regards animal intelligence, posits the following queries:—

But what was it that taught the beaver to dam back the flowing water by a regular weir built of tree trunks, sticks and branches, in order that some of the burrows which lead to the face of the river-bank from the building which it so skilfully constructs might be always under water?

What taught the ants to carry on regular agricultural operations, to collect the seeds of certain grasses, let them germinate, then to bite off the germ—to malt, in fact, and to dry the seeds, and keep them for future requirements?

My own answer is: symbiogenetic experience, that is, the age-long benefit accruing from their physiologically righteous feeding and other correlated habits has given them a margin for brain development along lines parallel to our own, however much less in degree.

The interesting facts concerning animal psychology and mentality now coming to light go a long way to justify Prof. Eimer's views and his further remark that people in general, and many naturalists, immensely under-estimate the mental faculties of animals.

Men have an idea they must at any price preserve their fancied exceptional position in the animal world, even though it be at the cost of their delight in nature, and of their own intellectual progress.

CHAPTER VII.

PSYCHOGENESIS.

A plant has memory in Hering's and Samuel Butler's sense of the word, according to which memory and inheritance are different aspects of the same quality of living things.—SIR FRANCIS DARWIN.

The complaint so often brought against me of not having made experiments is about as reasonable as complaint against an architect on the score of his not having quarried with his own hands a single one of the stones which he has used in building.

Buffon did infinitely more in the way of discovering and establishing the theory of descent with modification than any one has ever done either before or since.

Lamarck was the Lazarus of biology. I wish his more fortunate brethren, instead of intoning the old Church argument that he has "been refuted over and over again" would refer us to some of the best chapters in the writers who have refuted him.

Mr. Darwin wanted to move his generation, and had the penetration to see that this is not done by saying a thing once for all and leaving it.

Form is mind made manifest in flesh through action.

—SAMUEL BUTLER.

Tout dépend en définitive de la valeur que vous accordez à la vie de l'esprit.

Or n'est-ce pas une conséquence du darwinisme que de nous représenter l'évolution des êtres comme indépendante de toute visée? Ne nous découvre-t-il pas, dans leur ascension, une œuvre toute mécanique, la résultante de frottements et de tassements dans lesquels l'esprit n'a pas à intervenir? Pas plus qu'elle n'implique de visée, la théorie de la lutte pour la vie n'implique donc même l'effort.—C. BOUGLÉ.

The science of Psychology deals with matters too remote from the factors and the lines of thought dealt with in this volume to be more than superficially touched upon, and it is not intended in this chapter to enter into the intricacies of modern Psychology; but merely to emphasize the dependence

of mind upon the organism with which it is connected and through which it operates, and the consequent importance of symbiogenesis even in the evolution of mind. It is, of course, obvious that the main considerations upon which I lay stress in this, as in former volumes, viz., the importance of co-operation, service and exchange of surpluses, apply equally in the world of mind, and can be read (by whoso will) into any work dealing with the synthesis of human percepts into their higher forms of combination.

Incidentally I have thought it useful briefly to consider Samuel Butler's theory concerning mind and design in Nature, especially as put forward in *Luck or Cunning*, which is acknowledged as his most mature production.

Psychology recognises that the control of thought, equally with the control of movement, requires effort, and, further, that there is in Psychology as in Biology what may be called a principle of progressive differentiation or specialisation, and this, as well as the facts of reproduction and association, suggests a symbiogenetic explanation.

We have already noted that it is symbiogenetic evolution that makes possible margins of capital which are indispensable for higher developments of various kinds. Knowledge, sympathy, altruism, mutual aid and reciprocal differentiation can progress only in proportion as security of life—purchased by symbiotic labours—is on the increase.

We have also seen that individuality and consciousness have very deep roots, and that they are present, at least incipiently, in the most primitive forms of life. We have inferred that plantagens, for instance, and also the phagocytes in our body possess a kind of individuality, a kind of consciousness. We also found both plantagens and phagocytes to be busy members of symbiotic unions, *i.e.*, active agents of symbiogenesis. It seems as though all forms that can be seen to figure at all independently in symbiogenesis have also this in common, viz., that they are all endowed with a consciousness, similar in kind though different in degree. It seems,

further, as though the endowment varies with the degree of contribution to biological utilities, and that both general endowments and status were in direct proportion to the output of biologically useful work.

From such facts as these we have indeed essayed to deduce a rational scale of biological values with the aid of which to make profounder biological computations than has hitherto been possible.

We have spoken of symbiogenesis, the mutual production and symbiotic utilisation of biological values by the united and correlated efforts, *i.e.*, work, of all strenuous organisms, as resulting in a progressive transmutation of physiological currency of every description. In this organic "alchemy" we have so far only casually alluded to the simultaneous synthesis of mind, although, of course, it is of the utmost importance, and may be said to represent the very essence of the evolutionary process.

The importance of mind in evolution will be evident from a consideration of the famous Hering-Butler theory anent memory and heredity.

By advancing the theory that memory and heredity are practically identical, both men have rendered a signal service to modern thought, and Butler, in particular, by his insistence on the importance of that theory and by his brilliant and incisive criticism of Darwinism, Wallacism and Weismannism, has deserved, in my opinion, to rank high amongst "correctores."

It is in no small measure due to the heroic and totally unrequited labours of Samuel Butler, and in particular to his vindication of mind, that saner biological views than those of a generation ago are now emerging on every hand. Only those in somewhat similar position in championing unpopular thought can fully sympathise with the following remark of his:—"I am aware that what I may say on this head is likely to prove more interesting to future students of the literature of descent than to my immediate public."

According to Butler there is a substantial identity between heredity and memory, a "oneness of personality between parents and offspring," and further: "Ideas are like plants and animals in this respect also, as in so many others, that they are more fully understood when their relations to other ideas of their time, and the history of their development are known and borne in mind."

Is it indeed true that ideas share somewhat the physical life of plants and animals? If so, this suggests that they are also evolved and maintained by a kind of symbiogenesis—superposed on and parallel to that of physical genesis; and I believe this can be shown to be the fact. The improvement of the mind, indeed, not only requires effort, but at times a decided symbiotic effort, or "*élan*," i.e., a strong associative mental effort, taxing both mind and body, as everybody who has ever applied himself to hard study knows to his cost. Hence it is with the genesis of mind as it is with sexual genesis—it requires a complete and long-standing co-operation of the units involved. If we wish to have the highest achievements there must be provided, I submit, opportunities for the highest forms of domestic and biological symbiosis, which, I claim, are in the long run the best guarantees of *mens sana in corpore sano*. And this brings me to the chief point that I wish to urge in this connection. I believe these symbiotic factors to be so important in psychogenesis that to omit them is to lose sight of half the mechanism concerned in this evolution. We have already seen that Butler partly perceived the importance of these deep-seated synthetic factors, for when he says that food is very thoughtful, this is at least an adumbration of a close and sympathetic relation between food (and what it entails in work) and mind.

It was only necessary to see what the thoughtfulness of food amounted to, physically, psychologically and bio-economically considered, to extend this idea further in accordance with the law of symbiogenesis. Butler, indeed, in a fine peroration (*Luck or Cunning*), presenting his final

opinion on these subjects, suggests a kind of psycho-morphological alchemy, transmuting thought into substance and into form by work, *i.e.*, by systematic cumulative effort, both physical and mental.

Bodily form may be almost regarded as idea and memory in a solidified state—as an accumulation of things each one of them so tenuous as to be practically without material substance. It is as a million pounds formed by accumulated millionths of farthings; more compendiously it arises normally from, and through, action.

He could scarcely have been more explicit in emphasising “action,” which becomes “work” as soon as we look upon it from the wider biological point of view. Though morphogenesis require substances, yet what matters most is “action”; in particular, as we have seen, biological, *i.e.*, bio-economic action. Hence also, as we have seen, the adequacy of a substance for assimilative purposes depends so largely on the legitimacy of its derivation. I quote with a certain amount of sympathy Butler’s further inspiration.

Action arises normally from, and through, opinion. Opinion from, and through, hypothesis. “Hypothesis,” as the derivation of the word itself shows, is singularly near akin to “underlying, and only in part knowable, substratum”; and what is this but “God” translated from the language of Moses into that of Mr. Herbert Spencer. The conception of God is like Nature—it returns to us in another shape, no matter how often we may expel it. Vulgarised as it has been by Michael Angelo, Raffaele, and others who shall be nameless, it has been like every other corruptio optimi—pessimum: used as a hieroglyph by the help of which we may better acknowledge the height and depth of our own ignorance, and at the same time express our sense that there is an unseen world with which we in some mysterious way come into contact, though the writs of our thoughts do not run within it—used in this way, the idea and the word have been found enduringly convenient.

The theory that luck is the main means of organic modification is the most absolute denial of God which it is possible for the human mind to conceive—while the view that God is in all His creatures, He in them, and they in Him, is only expressed in other words by declaring that the main means of organic modification is, not luck, but cunning.

Butler tries to show that all hereditary traits, whether of mind or body, are inherited “in virtue of, and as a

manifestation of, the same power whereby we are able to remember intelligently what we did half an hour ago, yesterday, or a twelvemonth since, and this in no figurative but in a perfectly real sense."

This view points to a kind of accumulation of mental capital parallel to that of physiological capital, an almost identical storing power appearing to be concerned in each case.

If life be compared to an equation of a hundred unknown quantities, I followed Professor Hering of Prague in reducing it to one of ninety-nine only, by showing two of the supposed unknown quantities to be so closely allied that they should count as one. I maintained that instinct was inherited memory, and this without admitting more exceptions and qualifying clauses than arise, as it were, by way of harmonics from every proposition, and must be neglected if thought and language are to be possible.

He goes on to say:—

Among the things thus brought more comfortably home to us was the principle underlying longevity. It became apparent why some living beings should live longer than others, and how any race must be treated whose longevity it is desired to increase. Hitherto we had known that an elephant was a long-lived animal and a fly short-lived, but we could give no reason why the one should live longer than the other; that is to say, it did not follow in immediate coherence with, or as intimately associated with, any familiar principle that an animal which is late in the full development of its reproductive system will tend to live longer than one which reproduces early. If the theory of "Life and Habit" be admitted, the fact of a slow-growing animal being in general longer lived than a quick developer is seen to be connected with, and to follow as a matter of course from, the fact of our being able to remember anything at all, and all the well-known traits of memory, as observed where we can best take note of them, are perceived to be reproduced with singular fidelity in the development of an animal from its embryonic stages to maturity.

We have already supplied a symbiogenetic explanation of longevity. We have seen that it depends on the capitalisation of biological (social) values, which in turn depends on the establishment of valuable symbiotic, *i.e.*, sympathetic, biological correspondences. Hence the slow growth required to satisfy so many correspondences. Butler's remark merely

reminds us again that such capitalisation is not complete without a simultaneous capitalisation of psychological values. Length of days requires memory, and memory, like progressive survival, requires long symbiogenetic roots, *i.e.*, continuous symbiotic and altruistic relations, both so far as progeny and the biological environment are concerned. The wisdom that is said to be the companion of length of days is one that is mainly based on a sympathetic attitude towards life, which not only renders possible gradual capitalisation of physiological and mental values, but also forms the basis of the evolution of the higher feelings. Let us take an example. The parrot and the higher apes rank high in the biological scale by their powers of articulation (mimicry), by their sagacity, their social habits, and their longevity. Most prominent among the factors which have produced this result is that of strict cross-feeding, *i.e.*, their evolutionary path has been one of tolerable biological symbiosis, tolerable symbiogenesis.

The fact, moreover, that the examples of longevity are not confined to animals, seems a further confirmation of the view that longevity is connected with a fundamental symbiogenetic principle. We saw how the highly symbiotic lichens are characterised by slow growth and by longevity, and how this was closely bound up with their bio-economic and related biochemical functions.

We may, therefore, similarly consider memory as closely bound up with the gradual symbiogenetic transformation of the organic world; whatever mental "chemistry" there is being closely associated with the Bio-chemistry of the particular species. In this sense the old scholastic saying, that "*Nihil est in intellectu quod non fuerit prius in sensu*," is only too true. Butler continues:—

Take this view and the very general sterility of hybrids from being a *crux* of the theory of descent becomes a stronghold of defence. It appears as part of the same story as the benefit derived from judicious, and the mischief from injudicious, crossing; and this, in its turn, is seen as part of the same story, as the good we get from change of air and scene when we are overworked.

The main cause of sterility we have found to be lack of adequate reciprocal differentiation, and we can now likewise see that lack of physiological and biological reciprocity must have injurious effects upon mental development, and thus form an additional cause of sterility.

The law of symbiogenesis requires species to be serviceable, to accumulate surpluses in order to obtain mental remuneration; *i.e.*, socially valuable experience accruing only through service. Crossing *per se*, *i.e.*, in the absence of contribution to biological values, as we have seen, has no particular good effects; a truth which is now evident also so far as psychological effects are concerned. The same explanation applies, in my opinion, to Butler's criticism of Darwin's Natural Selection theory. According to him one of Darwin's weak places is his contention that there can be sustained accumulation of bodily wealth, more than wealth of any other kind, without experience, watchfulness and good sense presiding over the accumulation.

We have seen that what I have called the ancestral dynamics (the original "endowment") of a species—however depraved it may now have become, and whatever degree of design it may have been that originally entered into its composition—must have been of a nature to accumulate organic wealth by symbiogenetic conduct. The same factors that can at the present day be seen to make for organic wealth must have produced it in the past though with less complexity, and, as I have already stated in the previous chapter, though the consciousness involved was at first but incipient, yet the solution of the biological problem resolved itself from the first into the establishment of bio-economic relations with corresponding degrees of mentality and of "design." The symbiogenetic explanation thus may be said to give that symmetrical perfection to Butler's views which Prof. M. Hartog says they lack, and this without having recourse to a teleological explanation, to design of the "prescient-from-all-eternity" order, which

Butler deprecates as much as did Darwin. Butler's strong protest against the omission of every kind of "design" shows his remarkable independence of thought and the fearlessness of his attitude.

The accumulation of accidental variations, which owed nothing to mind, either in their inception or their accumulation, the pitchforking, in fact, of mind out of the universe, or at any rate its exclusion from all share worth talking about in the process of organic development, this was the pill Mr. Darwin had given us to swallow; but so thickly had he gilded it with descent with modification, that we did as we were told, swallowed it without a murmur, were lavish in our expressions of gratitude, and, for some twenty years or so, through the mouths of our leading biologists, ordered design peremptorily out of court, if she so much as dared to show herself. Indeed, we have even given life pensions to some of the most notable of these biologists, I suppose in order to reward them for having hoodwinked us so much to our satisfaction.

Happily the old saying "*Naturam expellas furcâ, tamen usque recurret,*" still holds true, and the reaction that has been gaining force for some time will doubtless ere long brush aside the cobwebs with which those who have a vested interest in Mr. Darwin's reputation as a philosopher still try to fog our outlook.

His ideas about design may be said to culminate in the remark that we must make the design manifested in organisms more like the only design of which we know anything, and therefore the only design of which we ought to speak, viz., our own! This has since been realised by other writers.

Our own design is tentative, and neither very far-foreseeing nor very retrospective; it is a little of both, but much of neither; it is like a comet with a little light in front of the nucleus and a good deal more behind it, which ere long, however, fades away into the darkness; it is of a kind that, though a little wise before the event, is apt to be much wiser after it, and to profit even by mischance so long as the disaster is not an overwhelming one; nevertheless, though it is so interwoven with luck, there is no doubt about its being design; why, then, should the design which must have attended organic development be other than this? If the thing that has been is the thing that also shall be, must not the thing which is be that which also has been? Was there anything in the phenomena of organic life to militate against such a view of design as this? Not only was there nothing, but this view made things plain, as the connecting of heredity and memory had

already done, which till now had been without explanation. Rudimentary organs were no longer a hindrance to our acceptance of design, they became weighty arguments in its favour.

“Continued personality and memory,” according to Butler, “are the elements that constitute experience.” He assumes a physical substratum of racial memory (inheritance), and, if this view prove correct, again we may thus see how greatly racial experience and wisdom, powers of will and of mind, must depend on symbiogenetic factors, which determine the quality of physical composition, and thus the health and the longevity of a race. “A race is one long individual living indeed in pulsations, so to speak, but no more losing continued personality by living in successive generations, than an individual loses it by living in consecutive days.” He further states that when he wrote *Life and Habit*, in 1877, “it was not generally seen that though the father is not nourished by the dinners that the son eats, yet the son was fed when the father ate before he begot him.”

I have long been struck by this important truth, which is yet far from being sufficiently realised. I am taking every opportunity, therefore, to emphasize the transcendent importance of ancestral feeding; *i.e.*, of feeding generally in its genetic effects. The food problem is not exhausted, though we have determined the extent to which successive generations are physically fed by the food of their progenitors; it remains still to elucidate the extent to which they are generally determined by ancestral feeding, *i.e.*, as regards psychical, biological, and evolutionary developments. The same injudicious fare that we have seen in the long run to be mainly responsible for “dragging evolution in the mud,” is also the bane of genuine mentality and of memory, militating, as it does, against psychological progress.

Quin corpus onustum

Hesternis vitiis animum quoque praegravat una,

Atque affigit humo divinae particulam aerae.

Butler cites Claude Bernard as saying: “Rien ne naît, rien ne se crée, tout se continue. La nature ne nous offre

le spectacle d'aucune création, elle est d'une éternelle continuation," to which he retorts: "but surely he is insisting upon one side of the truth only, to the neglect of another which is just as real, and just as important; he might have said, 'Rien ne se continue, tout naît, tout se crée. La nature ne nous offre le spectacle d'aucune continuation. Elle est d'une éternelle création'; for change is no less patent a fact than continuity, and, indeed, the two stand or fall together."

Here again Butler's view is superior and is backed up by recent philosophical and psychological opinions, and it may also be said to be congruous with my symbiogenetic view. The same may be said of the following:—

To think is to fuse and diffuse ideas, and to fuse and diffuse ideas is to feed. We can all feed, and by consequence within reasonable limits we can fuse ideas; or we can fuse ideas, and by consequence within reasonable limits we can feed; we know not which comes first, the food or the ideas, but we must not overtax our strength; the moment we do this we taste of death.

Modern Psychology looks indeed to subjective interests for the explanation of the synthesis of many important motor and sensory presentations (perceptions); expressed in Butler's phraseology: "Form varies as function and function as opinion concerning advantage." Modern Psychology here, however, relies upon Biology, which is notoriously backward in everything appertaining to nutrition, and hence it sadly misjudges the most important subjective interest of all, viz., food with all the psychological implications that it involves.

Butler's reference to food in this connection shows the depth of his insight, although he rests content with a general warning of the frequently precarious nature of the mysterious synthesis involved in the mutual relations between body and mind.

Looking (with Erasmus Darwin) upon a new generation not as a new thing, but as "a branch or elongation" of the one immediately preceding it, he tells us: "Instinct is knowledge or habit acquired in past generations—the new generation remembering what happened to it before it parted

company with the old. More briefly, instinct is inherited memory." And he adds the rider: "If a habit is acquired as a new one, during any given lifetime, it is not an instinct. If having been acquired in one lifetime it is transmitted to offspring, it is an instinct in the offspring though it was not an instinct in the parent. If the habit is transmitted partially, it must be considered as partly instinctive and partly acquired."

Butler thought that Charles Darwin was in reality in substantial agreement with, although apparently differing from, Erasmus Darwin on these matters, and he applies to the former the same criticism as to Romanes:—

He adopts, but (probably quite unconsciously) in his anxiety to avoid appearing to adopt, he obscures what he is adopting.

In Mr. Darwin's case it is hardly possible to exaggerate the waste of time, money, and trouble that has been caused by his not having been content to appear as descending with modification like other people from those who went before him. It will take years to get the evolution theory out of the mess in which Mr. Darwin has left it. He was heir to a discredited truth; he left behind him an accredited fallacy.

Butler, as is well known, of course, was "out" to discredit the "mindless theory of Charles Darwinian Natural Selection," and to substitute in its place a mindful theory of evolution (to which end he promulgated his own theory—which had already been independently formulated by Prof. Hering—regarding "unconscious memory"). What he has to say about incipient consciousness is throughout congruous with the place accorded to it in my symbiogenetic theory:—

Consciousness and change, so far as we can watch them, are as functionally interdependent as mind and matter, or condition and substance are—for the condition of every substance may be considered as the expression and outcome of its mind. Where there is consciousness there is change; where there is no change there is no consciousness; may we not suspect that there is no change without a *pro tanto* consciousness, however simple and unspecialised? Change and motion are one, so that we have substance, feeling, change (or motion), as the ultimate three-in-one of our thoughts, and may suspect all change, and all feeling, attendant or consequent, however limited, to be the

interaction of those states which for want of better terms we call mind and matter. Action may be regarded as a kind of middle term between mind and matter; it is the throe of thought and thing, the quivering clash and union of body and soul; common-place enough in practice; miraculous, as violating every canon on which thought and reason are founded, if we theorise about it, put it under the microscope, and vivisection it. It is here, if anywhere, that body or substance is guilty of the contradiction in terms of combining with that which is without material substance and cannot, therefore, be conceived by us as passing in and out with matter, till the two become a body ensouled, and a soul embodied.

All body is more or less ensouled. As it gets further and further from ourselves, indeed, we sympathise less with it; nothing, we say to ourselves, can have intelligence unless we understand all about it—as though intelligence in all except ourselves meant the power of being understood rather than of understanding.

This is, in my opinion, an admirable way of viewing life whole, and presents a creative evolution view not excelled even by Bergson. If all change is *pro tanto* consciousness and action, it is also *pro tanto* work; and if the very "soul" of a body is to consist, so far as we can see, of interaction, the significance of co-operation generally is likewise seen as enhanced.

Let us compare Butler's view with a quite recent one as stated by Dr. Arabella Kenealy (*Nineteenth Century*, July, 1914).

In the language of Biology the Brain and other nervous tissues are "highly phosphorised fats in a weak salt solution"; a description which shows a cold wet blanket—materialistic and impenetrable—whereof not a corner even has been lifted, dropped between us and the marvel of Mind.

If for "highly phosphorised fats in a weak salt solution" we conceive of the Brain as a living storage-battery of impressions in which, it may be, every molecule in every cell is charged with memories of antecedent forms, from the crystal onwards up through planes of vegetation, planes of the lower animal kingdom, and finally through primitive to civilised man; and if we assume that in such a storage-battery any thought or impulse is a complex of impressions accreted along its travel down incalculable ages, plus the last factor of the existing ego—a last grey cell added to its myriad earlier cells, to alter the equation of personality—are we not carried nearer to a conception of the truth? As

a complex of memories inherited from every previous plane and form of existence, planes and forms of which we have no recollection save such as may lurk in some underlying cell of consciousness to contribute its quatum when needed, so that a man may divine the way of an atom, the soul of a flower, the heart of a bird, by power of eddies stirring somewhere in him for remembrance, one understands better, surely, this luminous book of the Mind on every particle whereof Life has writ indelibly its wondrous story.

The brain and nervous system are thus a psychical organism which Mind has evolved out of Matter, and by means of which, in the ever closer and more complex association of itself with Matter, Mind manifests in Life.

That ancestral dynamics count for as much in Psychology as in Biology is again insisted upon by Butler:—

What it (the body) will think to its advantage depends mainly on the past habits of its race. Its past and now invisible lives will influence its desires more powerfully than anything it may itself be able to add to the sum of its likes and dislikes; nevertheless, over and above preconceived opinion and the habits to which all are slaves, there is a small salary, or, as it were, agency commission, which each may have for himself, and spend according to his fancy; from this, indeed, income-tax must be deducted; still there remains a little margin of individual taste, and here, high up on this narrow, inaccessible ledge of our souls, from year to year a breed of not unprolific variations build where reason cannot reach them to despoil them; for *de gustibus non est disputandum*.

The place of individual dynamics and of genius in the life of a race is thus also hinted at. Independent thought and action are frequently of transcendent value, as Butler's own example indeed bears out. But, contrary even to Butler's opinion, the Bio-dynamics here concerned are more than a mere matter of taste and of accident, and they depend rather more on bio-economic factors than on "fancy"; *i.e.*, even the personal equation is largely influenced by these pre-determining factors, to the influence of which much that is commonly ascribed to design or as lucky coincidence must be set down. That genius shall arise is not a mere matter of accident or of taste, nor even of a sudden jump, but it is due to the long protracted gestation of Nature (in Robert

Chambers' terms), *i.e.*, to a gradual symbiogenetic transformation which, as we can now see, is a very complex process, including a greater number of biological, psychological and bio-moral factors than has hitherto been supposed. The coming of genius requires generations of *mens sana in corpore sano*—of physiological and psychological integrity. The efflorescence may appear sudden and may find expression in a temporarily weak generation on the physical side, but the preparation and maturation have taken generations of costly efforts, though these may owe their highest embodiment in a genius to a happy blend in the particular generation. In the symbiogenetic sense it is profoundly true what Schiller wrote:

“ Mit dem Genius steht die Natur im ewigen Bunde;
Was der eine verspricht, leistet die andre gewiss.”

We have seen how symbiogenesis provides the explanation of longevity, of lateness of development, and of slow growth. This is how Dr. Arabella Kenealy refers to the slow mental growth of man (one of the slowest breeders in the animal kingdom!) in the interest of that mental higher-production which leads up to genius:—

In the Brain of man reflexes may well be delayed in order that the last individuality may pit itself against reflexes of every antecedent generation represented there, from the amoeba upwards; so resulting in action which is the sum of all that has gone before—with a final added factor.

(The higher the organism the more concealed and delayed, within normal limits, will be its response, in order to allow time and scope for mind and personality more and more to enter into the equation.)

Thus what is true of biological status is also true of mental status. Both depend largely on antecedents, on symbiotics, *i.e.*, on racial longevity, *i.e.*, on racial integrity. There is thus also good symbiogenetic reason for Goëthe's admonition:

Strebe hoch empor; aber die Liebe gebe
Deinem Streben die Richtung!

Some such adage also applies to a race which is to be fruitful in genius. We have seen that this involves more than ordinary loyalty: it involves what one might term cosmic loyalty, *i.e.*, faithfulness, to the great law of Creative (or Progressive) Life, which is the law of symbiogenesis. In this sense what Butler says is true, that what an organism will think to its advantage depends mainly on the past habits of its race.

Butler thinks that Erasmus Darwin and Lamarck—introduce uniformity into the moral and spiritual worlds as it was already beginning to be introduced into the physical. According to both these writers development has ever been a matter of the same energy, effort, good sense, and perseverance, as tend to advancement of life now among ourselves. In essence it is neither more nor less than this, as the raindrop which denuded an ancient formation is of the same kind as that which is denuding a modern one, though its effect may vary in geometrical ratio with the effect it has produced already. As we are extending reason to the lower animals, so we must extend a system of moral government by rewards and punishments no less surely; and if we admit that to some considerable extent man is man, and master of his fate, we should admit also that all organic forms which are saved at all have been in proportionate degree masters of their fate too, and have worked out, not only their own salvation, but their salvation according, in no small measure, to their own goodwill and pleasure, at times with a light heart, and at times in fear and trembling. I do not say that Erasmus Darwin and Lamarck saw all the foregoing as clearly as it is easy to see it now; what I have said, however, is only the natural development of their system.

I have already spoken of Bio-morality, of biological remuneration, of biological action and reaction, *i.e.*, of biological values in connection with bio-social conduct, in the light of which the above passages and many others in Butler's work and those also of Lamarck and Erasmus Darwin become, to my mind at least, far more intelligible. All these conceptions we have, at any rate, seen to be of the utmost practical importance in sifting the grain from the chaff in the world of life. I have also mentioned self-adaptation and self-pauperisation, which conceptions again are quite congruous with the ideas here set forth by Butler. It is clear that Erasmus Darwin

and Lamarck, just as Charles Darwin, Spencer and Butler, were all in their respective provinces pioneers of Bio-Economics, which, of course, it is comparatively easy to develop to-day owing to their various labours.

Butler warns us that the term "fittest" in survival can only apply to those variations into which "a moral and intellectual system of payment according to results has largely entered"; *i.e.*, as I would say, what "Selection" there is in Nature is in accordance with bio-economic qualifications. The same thing is really implied when Butler speaks of "the survival of those who know best how to turn fortune to account"; *i.e.*, those who have remained within the bond of symbiogenesis.

Butler's demurrer to Darwin's attempt at "pitch-forking mind out of the universe" is interesting, and, as I do not believe that Butler's biological writings have yet had their due, I feel justified in quoting him further at some length. Thus, as regards Darwin's remark that "we must suppose that there is a power represented by natural selection or the survival of the fittest always intently watching each slight alteration, etc.," he says:—

Mr. Darwin probably said:—"A power represented by natural selection" instead of "natural selection" only, because he saw that to talk too frequently about the fact that the most lucky live longest as "intently watching" something was greater nonsense than it would be prudent even for him to write, so he fogged it by making the intent watching done by "a power represented by," a fact, instead of by the fact itself. As the sentence stands it is just as great nonsense as it would have been if "the survival of the fittest" had been allowed to do the watching instead of "the power represented by" the survival of the fittest; but the nonsense is harder to dig up, and the reader is more likely to pass it over. This passage gave Mr. Darwin no less trouble than it must have given to many of his readers. In the original edition of the *Origin of Species* it stood, "Further, we must suppose that there is a power always intently watching each slight accidental variation." I suppose it was felt that if this was allowed to stand, it might be fairly asked what natural selection was doing all this time? If the power was able to do everything that was necessary now, why not always? and why any natural selection at all? This clearly would

not do, so in 1861 the power was allowed, by the help of brackets, actually to become natural selection, and remained so till 1869, when Mr. Darwin could stand it no longer, and doubtless for the reason given above, altered the passage to "a power represented by natural selection," at the same time cutting out the word "accidental."

He found his natural selection hung round his neck like a mill-stone. There is hardly a page in the *Origin of Species* in which traces of the struggle going on in Mr. Darwin's mind are not discernible, with a result alike exasperating and pitiable.

It is only too true that Darwinism has stagnated because of the ballast of "Natural Selection," the dead weight of which has had the effect of converting many Darwinists into Obstructionists. The violent objection to every attempt at values or ethics is a case in point. In order that every living being may be duly set down as "naturally selected" (by omnipotent "chance"), no rival factors such as Bio-morality must be conceded! You may speak of "callous" physical nature (because this helps to emphasize the concept of the "blind struggle"); but on no account must you use similar epithets with reference to organisms themselves. Anything approaching Bio-morality is strictly anathema in the eyes of Obstructionists. It must be rigidly denied or ridiculed. There is the organism, and there is its environment; and if the organism does not adapt itself in a manner to gain the "favour" of "Natural Selection," there is a speedy alternative for it—death. Voilà tout! Why trouble about morality which causes quite enough vexation in the human sphere! The denial of ethics is on a par with the denial of the well authenticated facts of the zoological distribution of disease, necessitated by the corollary that wild nature being thoroughly "naturally selected" cannot harbour disease. Yet, impressed by the facts of co-operation, a few fair-minded Darwinians are now admitting that "the selective process has to be envisaged in relation to the web of life." With co-operation and the time-element duly focussed, however, evolution becomes intelligible, as we have seen, as a qualitative process with a strong bio-moral sanction behind it and without needing any mysterious

operation of "chance" or of "Natural Selection." It is equally futile to plead that "Natural Selection" is but a convenient and innocent metaphor, reconciling every kind of peaceful endeavour with every form of ruthless conflict, every form of health with every form of disease. In reality the doctrine stands condemned by such bivocations, by the falsity of its implications, and likewise by the fruits it has borne in the socio-political sphere. "*Ogn' erba si conosce per lo seme.*"

Butler also tells us:—

When we speak of cunning or design in connection with organisms we do not mean cunning, all cunning, and nothing but cunning, so that there shall be no place for luck; we do not mean that conscious attention and forethought shall have been bestowed upon the minutest details of action, and nothing been left to work itself out departmentally according to precedent, or as it otherwise best may according to the chapter of accidents.

Like Spencer, Butler pointed to the analogy of the establishment of physiological and psychological capital with that of mercantile capital. That "cunning," however, even with the above proviso, is nevertheless insufficient as an explanation of success, but requires replacing by the more comprehensive symbiogenetic view, becomes further evident from the following otherwise quite reasonable passage:—

Granted, again, that there is no test more fallacious on a small scale than that of immediate success. As applied to any particular individual, it breaks down completely. It is unfortunately no rare thing to see the good man striving against fate, and the fool born with a silver spoon in his mouth. Still on a large scale no test can be conceivably more reliable; a blockhead may succeed for a time, but a succession of many generations of blockheads does not go on steadily gaining ground, adding field to field and farm to farm, and becoming year by year more capable and prosperous. Given time—of which there is no scant in the matter of organic development—and cunning will do more with ill luck than folly with good.

Although a large scale test may easily be superior to a small scale one, yet we can now in the light of symbiogenesis understand how Butler's rough test must frequently be totally inadequate. Mere cunning may, and very frequently does,

lead to an illusory kind of success, *i.e.*, one that is anti-social (anti-biotic), as, for instance, the "success" of parasites. Butler, of course, cannot help realising this truth; but his term lacks the bio-economic connotation, and he is obviously not aware to what an extent at least the lower forms of "cunning" actually deliver vast numbers of organisms up to degeneracy. Had he been fully alive to the range of pathogenesis on the one hand and to the importance of biological correspondences on the other, he would, no doubt, have been more emphatic on general integrity rather than "cunning," on righteousness and fellowship rather than short cuts to "success."

Whilst fully recognising Butler's great merit as a critic of thought, as a pioneer, and as a champion of the democratization of science, I am bound to say that he has failed almost as much, if not quite so signally, as Huxley in recognising the importance of the altruistic and symbiotic principles governing the evolution of life. More emphatically than Huxley he suggests "values" as an explanation of success, but even so only in a vague sort of way, and without providing any symbiogenetic (or, as one might also say, a true democratic) connotation of values. What he has to say about "cunning" is as open to vicious political interpretations as is Huxley's remark that you may "proclaim human equality as loudly as you like, Witless will serve his brother," and, further, that "the doctrine that all men are, in any sense, or have been, at any time, free and equal, is an utterly baseless fiction."

Evidently Huxley could on occasion discover values as determinants of status. But he stopped, as did Butler, half-way; or rather, it seems, that both men stopped at the point where their political and social prejudices began.

The former statement of Huxley is in order so long as it involves the recognition of the law of service according to values, which, when fully propounded, turns out to be the law of Symbiogenesis. True, Witless will serve his "brother"

(and, what is more, will do so quite willingly if his "brother" is really the better man, though frequently but a semblance of superior or erstwhile value be left), but the "brother" will nevertheless refrain from exploiting Witless, and will, on the contrary, do his best to render him adequate counter services and to raise his condition. It seems that Huxley could not rid his mind of the prejudice that the law of service also involves, at least to a considerable extent, a law of exploitation; *i.e.*, that it justifies a state of permanent and one-sided exploitation of one group by another, such as instanced in Nature by those numerous phases of parasitic exploitation, which, according to a corollary of the theory of Natural Selection, he is unfortunately constrained to regard as *normal*, but which, on the symbiogenetic view of evolution, we must emphatically set down as *abnormal* phases of life. Human society may quite justly put a premium on skill, intelligence and talent to encourage their growth; but the moment the man who "can" uses his "cunning" to claim more than his deserts, or to refrain from adequately serving his less fortunate brethren, his presence really defeats the objects of society, and, moreover, he, and frequently his progeny, too, become impediments who will suffer the consequences of surfeit.

Noblesse oblige. The highest dignitary of a State should be the first servant of the State. There is, therefore, plenty of scope for the political equality of men in the nobility of discharging their respective obligations to the State—each according to his own station in life, each according to his indispensable specialisation.

Democracy is by no means irreconcilable with the law of service according to status or values. On the contrary, what true democracy seeks is, precisely, values. No true democrat, no Rousseau, Ruskin or Tolstoy, would for a moment consider that a vicious man is equal to a virtuous, or a stupid equal to a wise man. It is, however, certain that democracy, unlike other systems, does in the long run assure the best mutual accommodation of men; *i.e.*, according

to values. That the principle of hereditary inequality of men underlying many non-democratic political systems is inferior, has its reason partly in profound biological facts, a matter to which we shall presently recur. Already it will have been evident to the modern reader that Huxley's second statement is, to say the least, an exaggeration. The more consistently men are treated as political equals, and their dignity as such is respected, the greater the growth of sturdy and independent character, of a virile nationhood with a sensitive national conscience, the more there will arise of self-reliance, self-help and of the highest forms of national co-operation. Such rule favours, as Ruskin says, the production of "thoughtful, sensitive, earnest, kind men, large in their views of life, and full of various intellectual powers." What is more, it brings to the front the most qualified amongst them—maligned and opposed though they generally are by cliques and inequality-prophets.

In the Koran it is laid down that "a ruler who appoints any man to an office, when there is in his dominions another man better qualified for it, sins against God and against the State." But the danger of transgression of this rule is far greater in a State where numerous feudal and other prerogatives exist, and where national co-operation is by coercion of one class by another rather than by voluntary action, and by the mutual consent of dignified, though diversified citizens. The practical test of a political system may be said to consist in the way in which it brings men to the front by merit rather than by favour or by mere cunning; by national service rather than by scheming, or by flattery of rulers.

It is not enough, by any means, that in a State the Witless serve the cunning. What is needed is that the system of mutual service in the community is of a (sympiogetically speaking) profitable character; *i.e.*, that it benefits the race and through it the world at large. The less there is of exploitation and the more of voluntary mutual assistance and of equal

opportunities for all, the less does any evidence of the inequality of men obtrude itself, the more will the community receive from every member his share of duty, and the better will the community as a whole progress towards the achievement of its highest objects.

Only a wrong interpretation of the fundamental laws of Nature or a fractional reading only of the evolutionary process could give rise to such political pessimism as that contained in Butler's and Huxley's views regarding the superiority of cunning and the permanent inequality of men. Seeing that mere "cunning" so frequently degenerates into mere "luck" (which, according to Butler, lacks a sufficiency of persistent principles to have produced organic evolution), a better title for a book that was to challenge the theory of natural selection would have been "Luck or Service," for only in service is there "bleibender Gewinn," only service can gain sweet rewards.

According to Butler, "life—viewed both in the individual and in general as the outcome of accumulated developments—is one long process of specialising consciousness and sensation.

"Livingness depends on range of power, versatility, wealth of body and mind."

What other but symbiogenetic factors may we trust to in order to maintain the highest forms of "Livingness"? As regards the line of demarcation between living and dead matter, he tells us:—

Is the line to be so drawn as to admit any of the non-living within the body? If we answer "yes," then, as we have seen, moiety after moiety is filched from us, till we find ourselves left face to face with a tenuous quasi immaterial vital principle or soul as animating an alien body, with which it not only has no essential underlying community of substance, but with which it has no conceivable point in common to render a union between the two possible, or give the one a grip of any kind over the other; in fact, the doctrine of disembodied spirits, so instinctively rejected by all who need be listened to, comes back as it would seem, with a scientific *imprimatur*; if, on the other hand, we exclude the non-living from the body, then what are we to do with nails that want cutting, dying skin, or hair that is ready to fall off? Are they less living than brain? Answer "yes," and degrees are

admitted, which we have already seen prove fatal; answer "no," and we must deny that one part of the body is more vital than another—and this is refusing to go as far even as common sense does; answer that these things are not very important, and we quit the ground of equity and high philosophy on which we have given ourselves such airs, and go back to common sense as unjust judges that will hear those widows only who importune us.

Evidently there are different degrees of "livingness," in substances as well as in animate bodies, and these differences, as we have seen, it is best to distinguish according to biological, *i.e.*, symbiogenetic values.

Butler concludes that "the only way out of the difficulty is to rehabilitate contradiction in terms, and say that everything is both alive and dead at one and the same time—some things being much living and little dead, and others, again, much dead and little living."

A better way, as I have said, seems to be to classify things according to their biological value. It is also necessary to recognise that some things, although living, are yet partly dead, precisely in so far as they have—according to an Emersonian metaphor—too much guano (impurities) in their composition, *i.e.*, through work being impaired.

As with life and death, so with design and absence of design or luck, Butler thinks "there is always a little place left for repentance; that is to say, in theory we should admit that both design and chance, however well defined, each have an aroma, as it were, of the other," and, he continues, "This having been explained, and it being understood that when we speak of design in organisms we do so with a mental reserve of *exceptis excipiendis*, there should be no hesitation in holding the various modifications of plants and animals to be in such preponderating measure due to function, that design, which underlies function, is the fittest idea with which to connect them in our minds."

There seems justice in Butler's contention that we cannot do entirely without "design," and his remarks may be said to find a practical illustration in the case of "love-foods"—a

term which, I doubt not, in the opinion of many who see nothing but "luck" in the evolutionary process savours too much of design. Sceptics, however, should remember that "love-foods" are literally possessed of "aroma" (aromatic substances vitally important in nutrition and in growth), the peculiar appeal of which to the biological complements may be fitly described as representing "design" in the respective relations. We have seen that "love-foods" serve a wide biological "purpose" concurrently with their utility for domestic purposes.

At a first glance it appears like chance when, say, an insect or a bird comes across a grain of "love-food," which the plant apparently only produces for its own purposes. It is by a mere accident, so it is thought, that the animal "devours" this grain only just because it "happens" to like it, or because it is hungry, and, in keeping with this "chance-view," the plant is very generally referred to as a typical, though accidental, producer, and the animal as a typical, equally accidental, depredator.

It is a wonderful kind of "chance," however, which has equipped these same "love-foods" with their remarkable "aroma" of design, their actual physical aroma, their high biological suitability, and, in short, with their symbiogenetic value! Certainly there we have a chance which in Butler's sense is wedded to design! Surely, if there be no other kind of design, there must always remain with us that design which is calculated to solve and in various ways to meet the bio-economic problem—which in a sense may be looked upon as the central issue of evolution. In *Evolution by Co-operation* I have already contrasted what one might call the "chance" view with the bio-economic view.

Thus, according to Dr. Wallace, it is chance which determines survival. Says he: "It is usually the amount of destruction which an animal or plant is exposed to, not its rapid multiplication, that determines its numbers in any country"; and, as he further states: "The abundance of a

species bears little or no relation to its seed-producing power." This, of course, savours of chance, and is supposed to be interpretable as such. How greatly, however, design enters into this chance is seen the moment we view Dr. Wallace's illustration in the light of Bio-Economics! He mentions the case of *Lantana mixta*, and says: "The fruit of this plant is so acceptable to frugivorous birds of all kinds that, through their instrumentality, it is spreading rapidly to the complete exclusion of the indigenous vegetation where it becomes established."

Dr. Wallace thus unwittingly contradicts his own destruction (*i.e.*, chance) theory, and shows that plants qualify for abundance by bio-economic usefulness, and that we have here design, though it be not of the "prescient-from-all-eternity order."

In the concluding chapter of *Luck or Cunning*, Butler has some important remarks on "feeling" which are again worth reproducing here.

Feeling is the art the possession of which differentiates the civilised organic world from that of brute inorganic matter, but still it is an art; it is the outcome of a mind that is common both to organic and inorganic, and which the organic has alone cultivated. It is not a part of mind itself; it is no more this than language and writing are parts of thought. The organic world can alone feel, just as man can alone speak; but as speech is only the development of powers the germs of which are possessed by the lower animals, so feeling is only a sign of the employment and development of powers the germs of which exist in inorganic substances. It has all the characteristics of an art, and though it must probably rank as the oldest of those arts that are peculiar to the organic world, it is one which is still in process of development. None of us, indeed, can feel well on more than a very few subjects, and many can hardly feel at all.

It is not a little significant to see Butler here using the term "civilised organic world" (held together by common "feeling"). I have spoken several times of "organic civilisation," and, indeed, I hope I have shown wherein it consists, how profound are its roots and how extensive its

operations. That the bio-economic and physiological operations of "organic civilisation" have throughout their psychological parallels and concomitants must now be clear. It is also now patent that we must seek to progress in the "art of feeling" quite as much as in every other bodily or mental art, in order to obtain the blessings of an enhanced symbiogenesis. Juvenal, that greatest of Roman "correctores," has expressed a similar thought:—

Mollissima corda

Humano generi dare se natura fatetur,

Quae lacrimas dedit. Haec nostri pars optima sensus.

Juvenal uttered these words as a protest against the inhumanities of his time—"cum in servum omnia liceant"! The time has now arrived for a more enlightened age to recognise not only the claims of down-trodden humanity, but also those of other down-trodden members of "organic civilisation." The law of compassion has long been preached. I submit that it can now be supplemented in the light of symbiogenesis, and be shown to be above all a Law of Nature.

CHAPTER VIII.

SCIENCE AND DEMOCRACY.

The abolition of personal slavery is the basis of the highest political hope that it can enter into the mind of man to conceive.—SHELLEY.

It is impossible to conclude, of any given mass of acquired wealth, merely by the fact of its existence, whether it signifies good or evil to the nation in the midst of which it exists. Its real value depends on the moral sign attached to it just as sternly as that of a mathematical quantity depends on the algebraical sign attached to it.

Luxury is indeed possible in the future—innocent and exquisite; luxury for all, and by the help of all; but luxury at present can only be enjoyed by the ignorant: the cruelest man living could not sit at his feast unless he sat blindfold.

The increase of both honour and beauty is habitually on the side of restraint.—The noblest word in the catalogue of social virtue is "loyalty."—RUSKIN.

Les institutions doivent accomplir les destinées de l'espèce humaine; elles atteignent d'autant mieux leur but qu'elles élèvent le plus grand nombre possible de citoyens à la plus haute dignité morale.

—SISMONDI.

Si l'on veut que la division du travail, au lieu d'être contrainte, devienne vraiment libre, il faut que d'égales possibilités soient ouvertes aux puissances inégales.

Mais toute morale scientifique n'est pas enfermée dans les conjectures de l'anthroposociologie, dans les métaphores de la théorie organique, dans les équivoques du darwinisme social.

On comprend mieux maintenant combien il était décevant d'attendre, d'une morale "scientifique" assise sur la biologie, qu'elle jugeât en dernier ressort du bien ou du mal fondé des aspirations égalitaires. En réalité le juge ainsi intronisé était incompetent d'une incompetence double.—BOUGLÉ.

Rousseau brought me to the right view. This blinding superiority vanished. I learned to honour men.—KANT.

I do not think the main conclusions arrived at in the foregoing chapters justify pessimism. The older theories of

evolution, although they otherwise proved fascinating and stimulating, have undoubtedly (at least in some quarters) given rise to a pessimistic view of life.

As regards Darwinism, I will quote Mr. C. B. Roylance Kent on the extent to which it has induced a fatalistic and politically baneful view to prevail. ("Evolution in Human Society," *Fortnightly Review*, June, 1913.)

It is hardly questionable, indeed, that the general acceptance of Darwinism has induced a view of life, an outlook on affairs, a standpoint, which are novel. There has arisen a sort of anti-humanitarian, even a fatalistic, way of regarding the destiny of man. Physical science, it is believed, has given its verdict in favour of violence and brute force; it is idle therefore, so it is argued, to endeavour to promote the finer feelings. Gentleness, humility, the sense of justice are, from this point of view, not so much virtues as symptoms of weakness and degeneracy. Natural selection, it is asserted, will go its passionless way, and, whether we wish it or not, the stronger will survive. Blessed are the strong, for they shall destroy the weak. That the race is only to the swift and the battle to the strong; that man's life and actions are ruled by inexorable laws which it is futile to endeavour to resist—this is the kind of mental attitude which the acceptance of Darwinism has caused very widely to prevail. The holding of such a creed cannot be without its influence upon conduct. Nor do the consequences end here. For the theory has penetrated into the region of high politics. It is, for instance, not too much to say that it has gone far to make popular a conception of the State which Bismarck, not altogether unsuccessfully, tried to realise. Man, it is now fashionable to hold, exists for the State, and not the State for the man. And so the individual withers and the State is more and more. In the competitive struggle between nations, safety it is asserted, can be secured only by realising this ideal. Now, it is precisely from this doctrine that the demand for extending the sphere of government interference and regulation is immediately derived; and from it, too, springs the conception of a nation as a self-contained unit—as "a moral, organised, masculine personality," to use the phrase of a German political philosopher.

I am in full agreement with Mr. Roylance Kent, and it is my firm belief (based on experience) that the Darwinian teaching has had some share in bringing about the present plight of Europe. Although apologists may say that Darwin himself held that human society had long abrogated Natural

Selection, and that therefore his teaching had been misinterpreted, yet it is only too well known that even at the present day many of his followers object to this abrogation of Darwin's Grand Functionary, relentless competition, as not in the best interests of the human race. A strong under-current of opinion has remained among numbers of men that at least from time to time the full rigour of "Natural Selection" (*i.e.*, starvation and death as the chief factor of progressive evolution!) had to be applied if the world was to be rejuvenated. If "Natural Selection" is a law of Nature—so runs the silent argumentation—it stands to reason that it must assert itself in the end over all man-made laws. True (so it is thought) there are always a number of sentimentalist or "weak-minded" people who cherish "fond illusions" of better things; but in the absence of scientific foundation for such optimist philosophy, and lest they should become involved in cant—the *materia prima* of the Devil, according to Carlyle—the "strong-minded" refuse to be "beguiled" by "sentimental stuff," preferring to pin their faith instead to the inexorable law of deadly competition.

Did not human history, at least in some of its more conspicuous episodes, also lend itself to an interpretation that seemed to support Darwinistic pessimism! Did not even a Carlyle—very preacher of the gospel of endeavour and hater of Darwinism—moved by the contemplation of so great a catastrophe as the French Revolution, exclaim: "The lowest, least blessed fact one knows of, on which necessitous mortals have ever based themselves seems to be the primitive one of Cannibalism: That I can devour Thee." "Et tous les temps sans doute ont entendu de ces déclarations pessimistes. Dante avait formulé la pensée que nous retrouvons sous la plume d'Anatole France: 'Nous faisons notre vie avec la mort des autres'" (Bouglé).

Did not both evolutionist and historian agree that that "arch-sentimentalist," Jean Jacques Rousseau, was an idle dreamer, if not an impostor (as they also, quite wrongly, at one

time seemed to agree that Lamarck was an inferior thinker—a “quantité négligeable”!). No one has been more denounced and maligned than poor Jean Jacques. (Lamarck was a poor struggler, and so at the present time is the superb Henri Favre!)

Yet the “contrat social” is capable of receiving a new setting and considerable vindication in the light of the “contrat social biologique”; i.e., of symbiogenesis; i.e., in the light of a symbiotic efficiency both sweeter and ampler than that advocated by Carlyle or taught by the schools.

Nor was Rousseau, with all his shortcomings, blind to the indispensable pre-requisite of a better physiological basis of human life, if a new era of hope was ever to dawn on the human race. Whilst his various critics, though equipped with infinitely greater facilities for such a task, refrained (owing to lack of insight and of courage) from the essential investigation of the physiological basis of life, and failing to discern the physiological path of progressive evolution, indulged instead in all manner of pessimistic lucubrations, Rousseau—whom they affected to treat with contempt—had in reality outshone them all by boldly stepping forward and tackling the greatest problems of life in a manner given only to the true pioneers of the human race. In emphatically condemning every sort of parasitic nurture, Jean Jacques not only gave utterance to the highest forms of democratic but also of evolutionary principles. When he tells us in the opening chapter of the *Emile ou De L'Education* that:—

Tout est bien, sortant des mains de l'Auteur des choses; tout dégénère entre les mains de l'homme. Il force une terre à nourrir les productions d'une autre, un arbre à porter les fruits d'un autre; il mêle et confond les climats, les éléments, les saisons; il mutile son chien, son cheval, son esclave; il bouleverse tout, il défigure tout; il aime la difformité, les monstres; il ne veut rien tel que l'a fait la nature, pas même l'homme; il le faut dresser pour lui, comme un cheval de manège; il le faut contourner à sa mode, comme un arbre de son jardin,

he is protesting against biological exploitation quite as much

as against human excesses, and he has the common-sense to perceive that the frequent causes of pessimism lie at home rather than with Nature.

Again he says (Book IV.):—

C'est moins la force des bras que la modération des cœurs qui rend les hommes indépendants et libres. Quiconque désire peu de chose tient à peu de gens, mais confondant toujours nos vains désirs avec nos besoins physiques, ceux qui ont fait de ces derniers les fondements de la société humaine ont toujours pris les effets pour les causes, et n'ont fait que s'égarer dans tous leurs raisonnements. Il y a dans l'état de nature une égalité de fait réelle et indestructible, parce qu'il est impossible dans cet état que la seule différence d'homme à homme soit assez grande pour rendre l'un dépendant de l'autre. Il y a dans l'état civil une égalité de droit chimérique et vaine parce que les moyens destinés à la maintenir servent eux-mêmes à la détruire, et que la force publique ajoutée au plus fort pour opprimer le faible rompt l'espèce d'équilibre que la nature avait mis entre eux.

This equilibrium of species in Nature to which Rousseau here refers, and a disturbance of which, according to him, leads to distorted social relations, distorted reasonings and distorted values generally, may be interpreted as the symbiogenetic equilibrium. We may read his protest as directed against every form of social and political exploitation, against predominance of brutal force over right. He pleads for true democratic restraint, democratic frugality and resulting democratic virtue and independence.

In all that is best in modern French thought we seem again to hear the voice of Rousseau, of his splendid message to the world. To quote again from Bouglé, as a typical representative of French sociology:—

En travaillant à abaisser toutes les barrières qui les séparent, et à ouvrir, au concours de tous, tous les cercles sociaux, il semble au contraire que la démocratie prenne des précautions très légitimes, pour la meilleure utilisation sociale des capacités naturelles

Or la demande des sociétés démocratiques est claire. Il leur faut sans aucun doute, pour les faire vivre et progresser, des peuples d'hommes forts, forts par le corps et l'esprit; mais il leur faut encore et surtout *des forts qui n'abusent pas de leur force*, qui sachent la consacrer au service de tous, et en limiter quand il le faut les exigences par le souci des droits des faibles,—des hommes forts par la conscience. Et c'est

pourquoi "*les plus aptes*" sous un pareil régime, *ceux dont il faudrait souhaiter par-dessus tout que le type allât en se multipliant*, seraient en effet "*les meilleurs*" au sens humain du mot, les individus capables d'accepter allègrement tous les devoirs de la solidarité. (*Italics mine.*)

C'est tantôt dans le sentiment individualiste, tantôt dans l'esprit social que nous avons aperçu ces cordes nécessaires, sans lesquelles les âmes ne vibreraient pas. Au vrai l'idéal démocratique a besoin, pour vivre, que ces deux aspirations coexistent ou plutôt s'allient étroitement; et celui-là qui pense que nécessairement elles s'excluent, prouve qu'il n'a pas compris la véritable essence de l'égalitarisme moderne, qui est précisément la synthèse de l'une et de l'autre.

Men may not all be equal, and are certainly not all fitted for one and the same position—nor is democracy indeed "*le droit pour tout bottier de diriger les navires en pleine mer*"—but the inequality of men is surely not so great as to justify the exorbitant claims preferred in all centuries by castes, cliques and tyrants against their fellow citizens, or even against other nations. All organisms, including man, are certainly equal in that they are responsible members of the web of life, all apparently descended from a common ancestor. They are all alike in Robert Louis Stevenson's words, condemned to some nobility, as they are also—individually and collectively—under the doom of frailty. Truly, as soon as we come to think of it, there is great equality in nobility, in frailty, and in death! Universally also it is true that no sooner has a genuine advance, though ever so fractional, been gained by strenuous endeavour, than frailty supervenes and the particular prerogative is abused and lost by the indulgence and excesses of subsequent generations. It is universally observable that whenever superiority has been gained by dint of greater intelligence and greater virtue, this is very soon equalised by relaxations of the respective efforts, or by relaxations of another kind. Herein also lies some biological explanation of the equilibrium of species in Nature whereof Rousseau speaks. "*Was von den Vätern du ererbt, erwirb es um es zu besitzen.*" This should spell at least equal opportunities for all.

All experience of human life goes to support the almost paradoxical view that aristocracy comes to an end with its arrival, that it shows little permanence, that a real and lasting inequality of men will not establish itself, though a gradual and general uplift supervenes. Aristocracy frequently ends *in*, but just as frequently *with* palaces. "Leurs privilèges mêmes les étouffent," as Bouglé says. And, indeed, Ruskin has it: "Out of the peat cottage come faith, courage, self-sacrifice, purity and piety, and whatever else is fruitful in the work of Heaven; out of the ivory palace come treachery, cruelty, cowardice, idolatry, bestiality—whatever else is fruitful in the work of Hell."

Really, therefore—notwithstanding even anatomic and genetic differences—men are not so very unequal, and that is also why it is said that the Lord, who sees the heart of men, is not a respecter of persons. It is good reason also for all democracies to take heart of grace and not to heed over much the prophets of permanent and fundamental inequality.

Huxley—Darwin's "bull dog"—who unfortunately went too far in his otherwise beneficial anti-obscurantist campaign, conceived a prejudice against Rousseau, and spared no efforts to disparage the latter's joyous and optimistic message to the world. Yet Huxley boasted that he was neither an optimist nor a pessimist; rather superior in this respect, as it would seem, to most successful men who are usually inclined towards a generous optimism. But when he, as the chosen representative of Science, declared that our human morality has not the sanction of Nature (Nature being decidedly non-moral), that the ethical process is in opposition to the cosmic (*i.e.*, the unconscious, unintelligent process of the sub-human world), that there is no trace in Nature of moral purpose (this being an article of exclusive human manufacture), that no ethics are required merely to survive, that the "fittest" to survive in the Struggle for Existence may be and often are the ethically (!) worst, when he scornfully rejected the idea that the principle of evolution could be adopted as an ethical principle, we begin

to see that such dicta taken alone were well calculated to scatter doubt and pessimism broadcast.*

Moreover, Huxley's own vaunted philosophic neutrality is thus in reality found to be due to the fact that he for one was too guarded to consider that there was a sufficient foundation for a reliable philosophy of (at least) human life to be raised upon the Darwinian theory. Whilst his vehement utterances with all their weight of "authority" were leading the then civilised world into pessimism, he vaunted his own non-pessimism in the face of it all. Huxley's very vehemence—which had the further injurious effect of intimidating all lesser scientific and literary "lights" ever since his mighty days, and of rendering the very thought of ethics in connection with Science "taboo," ought really to have put us on our guard and made us doubt the reasonableness of many of the great comparative anatomist's pronouncements.

I would not deny for a moment Huxley's great services to science and free-thought, nor his occasional fair-mindedness, so far as even ethics are concerned. I am far from inferring that he, any more than Darwin, was animated by any but the loftiest motives. What is unfortunately true, however, is that as in the case of Nietzsche and of Treitschke, the evil effects upon the minds of the people of their pessimistic utterances far outweighed those which their otherwise good intentions might have had.†

* The Encyclopædia Britannica says:—"This approaches pure pessimism—Huxley's latest speculations on ethical problems are perhaps the least satisfactory of his writings." This frequent survival of the "ethically worst"—really another admission of values—is, of course, no argument against evolutionary ethics. The difficulty lies in the inability to perceive that mere survival is no criterion of success because frequently associated with pathogenesis. It appears that Nature after all is not quite so intently bent on destruction as the Darwinian theory demands, but is, on the contrary, wisely magnanimous. "Peradventure" there may be some use that we do not as yet fully realise even in a backsliding species. Rather than concede that there may be something wrong with their conception of survival, however, Darwinians insist on the inversion that the wrong rests with Nature. They insist that Nature shows a complete disregard for ethics, and that the "ethically worst" in so far as they anyhow contrive to survive must be classed among the fittest, that the liver-fluke is the evolutionary peer of the philosopher.

† The Right Rev. Bishop Mercer, writing in defence of Darwinism (Nineteenth Century, February 1915)—*tempora mutantur*—believes that Nietzsche is not without excuse for his lack of focus, that there is a wide-spread suspicion that the case against Darwinism is a strong one, and that it cannot be denied that evolutionists have unfortunately laid such stress upon the factors of conflict that they themselves have been tempted to accord it a lonely throne.

Sometimes I have tried to think that Huxley and his school, when using the metaphorical phrase "the struggle for existence," entertained at least vaguely a kind of mental reservation anent the value of the underlying operation of natural co-operation. Such hopes, however, are quickly dispelled on coming across passages such as Huxley's likening the world to a gladiator's show, and telling us that even in the past history of mankind the essence of the struggle for existence is constituted by self-assertion, by the unscrupulous seizing of all that can be kept; in short, by those qualities which man "shares with the ape and the tiger." Can anyone expect anything but mischief to arise from such statements? Again: "The practice of that which is ethically best—what we call goodness or virtue—involves a course of conduct which, in *all respects*, is opposed to that which leads to success in the cosmic struggle for existence." (*Italics mine.*)

This is, I believe, a great exaggeration if not an actual mis-statement of the facts, as I in this and in previous books claim to have shown. Prof. Bergson and various other writers have already protested against the fallacies of Huxley's Romanes lecture from the point of view of continuity, by pointing out that there could not have been this break between prehuman nature and ethical man as postulated by Huxley, and likewise by pointing to the moral damage arising from his emasculation of the conception of the moral ideal.

I believe that what applies equally to the subhuman as to the human world has been very aptly expressed by another French writer (Joubert) thus: "C'est la force et le droit qui règlent toutes choses dans le monde; *la force en attendant le droit.*"

It is the breaking of the law—be it from inexperience, ignorance or perverted instincts—that causes the suffering and those struggles which extreme Darwinists seem to think constitute the all-in-all of Nature's methods. True, as we have seen, the keeping of the law of progress involves in the main persistence of behaviour along a narrow path. One wonders

why the discovery of this biological path proved so difficult or uncongenial a task to so eminent and astute a scientific thinker as Huxley, who otherwise protested that the only freedom he cared about was the freedom to do right, and confessed that the possibilities of wrong are infinite. Perhaps the personal equation was to be blamed for his inability on that score, as a brief consideration will show. With reference to his contemptuous references to Rousseau it is to be remembered that he also said: "It is not to be forgotten that what we call rational grounds for our beliefs are often *extremely irrational attempts to justify our instincts.*" (Italics mine.)

If only Huxley had employed a more self-denying ordinance by living and speaking up to this recognition and had thus modified his all too exuberant pronouncements, the world might have been spared a good deal of irrationality and of consequent mischief.

The *Times* (7/1/15) says that the world owes more to Huxley than it always remembers; but that "he did not wholly escape the controversialist's fate—the inability to see fully an adversary's position; proneness to overstate his own good points—we had almost said colour blindness, except as to party hues." . . . "To lay the foundation of a new morality upon the 'improvement of natural knowledge' was to rest his foundation upon one stone where several were needed."

What distressed Huxley so profoundly was the fact that frequently "the wicked flourishes like a green bay tree," while "the righteous begs his bread." In this we can at least sympathise with him. However, in his famous Romanes Lecture he gives vent to his grievance thus: "If there is a generalisation from the facts of human life, which has the assent of thoughtful men in every age and country, it is that the violator of ethical rules constantly escapes the punishment which he deserves"; and he adds that "Greek and Semite and Indian are agreed upon this conclusion." Here we must differ, as many, no doubt, have differed from him before. The prevailing note of the Scriptures is quite the opposite to that

represented by Huxley, and so are the lessons from Physiology. Both Scriptures and modern Physiology may be said to be in agreement that "As righteousness tendeth to life: so he that pursueth evil pursueth it to his own death." The study of Eugenics more particularly corroborates the saying that "There is that maketh himself rich, yet hath nothing: there is that maketh himself poor, yet hath great riches."

The Scriptures fully recognise, what is also clear to the Symbiogenist, that frequently, and for a time, "the wicked doth compass about the righteous"; but they are equally emphatic that the righteous alone can obtain enduring gains. "An inheritance may be gotten hastily at the beginning: but the end thereof shall not be blessed." "Yet have I not seen the righteous forsaken, nor his seed begging their bread." "Whatsoever a man soweth, that shall he also reap," etc., etc.

Huxley's, no doubt, is a case of "*Un poco di vero fa creder tutta la bugia.*" We shall not, therefore, accept his totally unwarranted verdict that there is no sanction for morality "in the ways of the cosmos," and that "brought before the tribunal of ethics, the cosmos might well seem to stand condemned." Neither shall we agree with his remark that "After the manner of successful persons, (sic) civilised man would gladly kick down the ladder by which he has climbed."

Man's advance was by symbiogenesis. All that he has done in opposition to the principles involved he has reason to regret; for it has led to the extinction of many of his races and never to genuine success.

It is a pity that it was not given to Huxley, who, as we see, was not without his own particular brand of sentimentalism, to recognise the symbiogenetic steps in the ascent of man. "*Tal ha belli occhi che niente vi vede.*" He concedes nobility and sanity to the Stoics, and admits that their summary of the whole duty of man, "Live according to Nature," would seem to imply that the cosmic process is an

exemplar for human conduct. "Ethics would thus become applied Natural History."

But, nevertheless, he will have none of it, and inveighs instead ferociously against "philosophasters" and "moralizing sentimentalists" who have made "confused employment" of such tenets. "Per picciola cagione pigliasi il lupo il montone"!

Had the Stoics but seen that "cosmic nature is the very *headquarters* of the *enemy* of ethical nature"! (Italics mine.) There must have been something wrong somewhere with these otherwise admirable men! He surmises that they were the descendants of "joyous fighting men" who with all their warlike qualities had found the cosmos too strong for them, who had become "sicklied o'er with the pale cast of thought," and were now seeking "salvation in absolute renunciation."

Huxley's arguments, of course, are in part already answered by what has been said about Symbiogenesis. Nor was it (rebellious) man that established Symbiogenesis; but Symbiogenesis established man. Ethics, indeed, accounts for Evolution quite as much as Evolution accounts for Ethics. In the beginning Ethics was little perceptible, and so was Evolution. The share of the universe in the begetting of man, however, must have been positive and great.

We shall allow, of course, that Huxley, like Wallace and others, was greatly devoted to his master Darwin, whose great example of work and whose great personality had deservedly won him numerous apostles. The disciples thought they beheld a new world, and in their enthusiasm they became rhapsodical.

The true Huxley, no doubt, belonged to a pure enough species of reformer. "Anaphylactised" with the poison of "Natural Selectionism," however, which he was never really able to assimilate, he was never quite the same again. He became a "Zucht-wahl" prophet *par excellence*—a variety of which Europe has since produced several psychologically and physiologically interesting specimens. One might have written

of him what Heine said of Goëthe: "Die Eulen verkrochen sich" (The owls were forced to retire), had he not been so strangely over-zealous in the service of his "proprio santo." As it is, his propaganda unfortunately scared away many useful birds, many desirable songsters with the owls, and one might rather apply to him: "So haben wir den Gift an tausende gegeben" (Thus we to thousands did the poison give).

Are we not driven at the present day by the logic of events to a similar mental metamorphosis (wishing to trust rather than defy the cosmos) as that ascribed by Huxley to the ancestors of the Stoics? Is not history repeating itself? We are reminded by *The Times* (11/2/15) that: "In future science, if it is not to be discredited, must be used to make us all more sane."

Why not, indeed, return to some of the prescriptions of the ancient Stoics, which appealed to so many of the noblest spirits of antiquity? The cardinal virtues of the Stoics were wisdom, courage, justice and discretion, and it is said that "it was the active, social, and severely self-denying principles in the standard of duty inculcated by the Stoics that commended their philosophy to the preference of the noblest spirits of Rome."

Stoic frugality meant true independence, which resulted in love of Truth, Peace, Justice, Honour and Liberty. Is there no appeal in this to the modern man? And, if not, what is it that bars the way? Why not also seek inspiration from the similar teachings of Gautama, the Buddha, the "Light of Asia," of whom Huxley in a wiser (differently inspired) moment declared: "By the inculcation of love and benevolence to all sentient beings, he practically levelled every social, political and racial barrier."

Great developments, I believe, are in store for that nation which, by a co-operation of reforms, knows to make practical application of such ancient wisdom combined with the teachings of symbiogenesis. With the socio-political measures that might be taken to hasten this consummation, I hope to deal on some future occasion.

In an Editorial (*Science Progress*, Jan., 1915), Sir Ronald Ross has the following pathetic reflection anent the present war:—"In this antithesis the mass of humanity must face the alternative accusations—that it possesses either the heart of the tiger or the brain of the fool." Would-be pacifists will do well to remember that in so far as large masses of mankind are still animated by the tiger's instincts, in so far as we are still breeding men "with too much guano in their composition" ("vulgar fractions" in Ruskin's phraseology)—and therefore apt to be of a tyrannical disposition and brutalizing others—we must expect a frequent recurrence of the Huxleyan "Struggle for Existence," with occasional recourse to the "terrible medicine" of war.

Regenerative efforts should be directed towards the physiological as well as the political emancipation of mankind. Indeed, to fail in this respect means "a lazy compliance with low conditions," and constitutes our chief sin of omission, as has been well perceived by Shelley, Tolstoy, Ruskin and others. Ruskin, speaking on æsthetic, ethical and economic grounds, warns us that:—

No longer among the individuals of the race is there equality or likeness, a distributed fairness and fixed type visible in each; but evil diversity, and terrible stamp of various degradation; features seamed by sickness, dimmed by sensuality, convulsed by passion, pinched by poverty, shadowed by sorrow, branded with remorse; bodies consumed with sloth, broken down by labour, tortured by disease, dishonoured in foul uses; intellects without power, hearts without hope, minds earthly and devilish; our bones full of the sin of our youth, the heaven revealing our iniquity, the earth rising up against us, the roots dried up beneath, and the branch cut off above; well for us only, if, after beholding this our natural face in a glass, we desire not straightaway to forget what manner of men we be.

What are we to expect from such a humanity? Ruskin, though he has somewhat overdrawn the picture, is yet quite different from writers of the class of Nietzsche, in that he preserves a loving regard for "simple humanity" and sympathy with the "lower creatures." He recommends the

abolition of great inequalities (wrongly established), both nationally and internationally. He looks forward prophetically to the day when England will "cast all thoughts of possessive wealth back to the barbaric nations among whom they first arose; and that, while the sands of the Indus and adamant of Golconda may yet stiffen the housings of the charger, and flash from the turban of the slave, she, as a Christian mother, may at last attain to the virtues and the treasures of a Heathen one, and be able to lead forth her Sons, saying: "*These are my Jewels.*"

Like Gautama, Coleridge, Shelley and Tolstoy, he also advises:—

Never to blend our pleasure, or our pride
With sorrow of the meanest thing that feels;

for there is not any virtue the exercise of which, even momentarily, will not impress a new fairness upon the features: neither on them only, but on the whole body, both the intelligence and the moral faculties have operation; for even all the movements and gestures, however slight, are different in their modes according to the mind that governs them; and on the gentleness and decision of just feeling there follows a grace of action, and, through continuance of this, a grace of form, which by no discipline may be taught or attained.

How cruelly Ruskin, whose cardinal doctrine was that reform from without must be complemented by reform from within, and who held with Milton that peace has her victories no less renowned than those of war, was ridiculed by many of his contemporaries! Yet how startling the influence of his ideas upon recent progressive developments in the government of the State! Quite the reverse of the influence of Darwinian ideas! Every nation has its own dominant philosophy. Either it is one of which Ruskin is typical, or it is one of which that of Hobbes or of Nietzsche is typical. Either it contains the germs of life or the germs of death.

Huxley's instincts, on the other hand, inclined him towards the "forceful" opinions of the fighting class. He shared with these a kind of biological antagonism to "sentimental" democrats who feel instinctively drawn towards

Rousseau and his like. It is a kind of bias that we may presume the predaceous types in Nature to feel towards the cross-feeders. Rousseau, as we have seen, favours cross-feeding.

We must give credit to Darwin's "bull-dog" for at least feeling some qualms of conscience anent his treatment of "poor" Rousseau. The world, however, owes infinitely more to cross-feeders than to the tiger class, and—in justice it must be conceded—it owes much more to Rousseau than to Huxley.

It is now evident also that by reducing the concept of evolution to the truism that whatever has survived was the fittest to survive, Huxley and his friends have stripped evolution of its greatest glory, viz., that the result of its operation has been to bring about by persistent bio-economic principles a constant if gradual and often interrupted rise of type by higher organisation, greater efficiency and increasing mutuality of relations resulting finally in the ethical human world as we see it in opposition to the blind struggle of forces.

The older and cruder view did not get over the difficulties of accounting for ethics or (as we have abundantly seen) for economics, for values, for positive and negative physiological factors, for metabolic factors in particular, for digestive transformation, etc. It ignored entirely the universal importance of symbiogenetic factors.

How well justified, more probably than he himself knew of, was Butler when he stated that it will take years to get the evolution theory out of the mess in which the Darwinian school had left it!

False thinking must in the end lead up to false action, and ultimately to great catastrophes, as it has done in this case. "Les erreurs de nos jugements produisent l'ardeur de tous nos désirs," as Rousseau puts it; and Huxley himself so pregnantly warns "practical" people that: "It is a matter of the very greatest importance that our theories of things, and even of things that seem a long way apart from our daily lives,

should be as far as possible true, and as far as possible removed from error."

Fortunately "hope springs eternal in the human breast," and the world turns aside from pessimists as soon as it finds out that their teachings cannot stand the tests of practice. The sound instincts of (democratic) mankind turned aside from "evolution by natural selection"—a case of merited neglect. "Quoi d'étonnant, dès lors, si les partisans de la démocratie s'inquiètent peu de ses métaphores pessimistes"? (Bouglé).

Attention has lately been drawn in the daily press to the following prophetic passage from the late George Gissing's book, *Henry Reyecroft*, as displaying a remarkable prescience in the light of recent events:—

I hate and fear science because of my conviction that for long to come, if not for ever, it will be the remorseless enemy of mankind. I see it destroying all simplicity and gentleness of life, all the beauty of the world. I see it restoring barbarism under a mask of civilisation. I see it darkening men's minds and hardening their hearts. I see it bringing a time of vast conflicts which will pale into insignificance "the thousand wars of old," and, as likely as not, will overwhelm all the laborious advances of mankind in blood-drenched chaos.

Another writer, Allen Upward, in his remarkable book, *The New Word* (1908), says, somewhat prophetically, by way of protesting against "what is falsely called Science as well as against what is falsely called Religion":—

I am looking a thousand years ahead, and watching other generations breaking asunder other swaddling bands. I want those bands to be less hard to break. Hardmindedness is the particular shape of Materialism that I dislike most, and deem to be the greatest foe to happiness.

Did not Ruskin also prophetically declare:—

I could smile when I hear the hopeful exultation of many, at the new reach of worldly science, and vigour of worldly effort; as if we were again at the beginning of days. There is thunder on the horizon as well as dawn. The sun was risen upon the earth when Lot entered into Zoar.

It is clear that the appreciation and the fair fame of science, like that of every other good cause, must suffer from

extremes, from one-sidedness and from mis-applications. Man's place in the universe had long been determined before the pseudo-discoveries anent "Natural Selection" seemed to claim radically changed interpretations. There were the Scriptures and the ancient sages, expressing the "sublimed" and "matured" phylogenetic experience of the human race; there was Seneca declaring that "*ubicumque homo est, ibi beneficii locus est*," and Goëthe: "Edel sei der Mensch, hülfreich und gut." There is nothing in modern Science really to invalidate such ancient wisdom.

How well some of the modern French school of sociologists have perceived the symptoms of danger and estimated the actual and prospective damage due to "Natural Selectionism," will be evident from the following passages from Bouglé's work (1909):—

Les vivants sont condamnés à une lutte sans relâche et sans merci. Vainement les hommes essaieraient-ils d'éluder cette nécessité naturelle. Toute la philosophie du monde vient s'y briser. Si l'on ne veut pas être mangé, il faut bien manger les autres. Les aphorismes de cette marque sont monnaie courante, dans les discussions contemporaines. Suivant M. Fouillée, la philosophie qu'ils représentent—celle des loups et des grands carnassiers—serait *précisément l'inspiratrice des efforts dirigés contre la culture classique humaniste et libérale*. "Armez-vous pour les luttes de la vie," voilà ce qu'on répéterait aujourd'hui aux jeunes gens. Et on leur apprendrait à mépriser tous les enseignements qui ne leur assurent pas, en vue de ces luttes, un avantage personnel, toutes les *idées qui ne sont pas des armes*.

The seeds of such "Zucht-wahl" doctrines have unfortunately found a congenial soil in Continental countries susceptible to theories of this kind, and the harvest is now (September, 1914) in course of being reaped. One day I trust the civilised world will understand that the evolutionary process is calculated to develop nothing to a greater degree than ethics. Purified by its sufferings, the world will realise the falsity of many pseudo-discoveries, and it will listen again eagerly to the new and more gladsome tidings of an evolution theory, brought up to date in ethics, which as I hope I have shown begins in a sense in the sub-human world, wherever the

law of co-operation over-rides that of competition. For it will be seen on any careful review of biological history that never at any time have organisms been permitted to go their own way unchecked and uncontrolled by other than selfish considerations, or to follow for long the path of least resistance as far as appetites and desires go except at their own risk and to their own injury.

Never at any time has the world of life been able to dispense with restraint, with mutual aid, with mutual forbearance and with nobility of life as main stays of organic existence, even, as I maintain, in the sub-human world. Never at any time has the weal of one really consisted in the woe of another. Never at any time has competition been more than an instrument of efficient co-operation. Never at any time has parasitism or any conduct in accordance with Dr. Pangloss's philosophy led to more than transient success. Never at any time have physiological transgression or excess and abuse of power been allowed to proceed with impunity. On the other hand, it cannot be denied, temptations have been many, great numbers have stumbled, and innumerable failures can only with difficulty be accounted for in the light of considerations embracing (as far as possible) the "ensemble" of life and its past.

But, even so, the vast sphere of pathogenesis—representing the doom of frailty as well as the retributive regularisation of efficient co-operation—must be fully accounted for before we can inveigh against Nature or bring any charges of callousness, wantonness, or cruelty against her. Underneath it all the constant tendency throughout has been towards more strength, more health, more resistance to disease, more harmony and perfection of organisms and their mutual relations; in short, towards ever greater physiological and psychological values. To what an extent this credit side of the account over-balances the debit side can only be fully grasped, I assert, in the light of the principle of symbiogenesis as operating on a large scale in the past and present of the organic world.

Some of our less extreme Neo-Darwinists are indeed inclined to think that "the struggle for existence is often a peaceful endeavour after well-being." But as it is now clear that the study of co-operative factors has hitherto been sadly neglected—although they are indeed of the greatest consequence—is it not somewhat paradoxical to say that "Struggle" includes or is synonymous with "peaceful endeavour"? Is this not saying, in other words, that co-operation is synonymous with competition?

Has not the time arrived to replace all vagueness concerning these alternatives by explicitness—at least in scientific disquisitions? Instead of mixing them up in metaphors we need to demonstrate under what circumstances the one becomes alternative or merely complementary to the other; *i.e.*, to demonstrate the laws which govern co-operation and competition respectively.

In my opinion "peaceful endeavour" applies to symbiosis, whilst "struggle" (in particular "the law of battle" as propounded by Darwin and others) refers chiefly to the opposite category, *viz.*, anti-biotics. Darwin concluded in the *Origin* that "from the war ('peaceful endeavour'?) of nature, from famine and death (?) the most exalted objects which we are capable of conceiving, namely, the production of the higher animals, directly follows." We can forgive Darwin this one-sided emphasis of the competitive factors, seeing that he had given particular care to the study of this phase of life (which we may therefore assume to have bulked rather formidably in his mind). He at any rate was the pioneer who had shed a flood of light on this peculiarly fascinating subject, which, in the days of obscurantism, needed urging, if only as a prelude to the still more important, though less conspicuous, subject of co-operation (which would indeed seem to require special emphasis in these latter days of militarism).

We may likewise excuse Darwin for making a sweeping metaphor do (substitute) service pending the lack of systematic study and knowledge concerning the fundamentally important

co-operative (symbiotic) factors which, indeed, he had not entirely overlooked, though insufficiently appreciated.

But now with the study of symbiosis more advanced it is possible to be more explicit than in Darwin's days. We can now rationally distinguish between co-operative and competitive factors and their respective spheres of action; and, what is more, bring the light of the science of Economics to bear on the phenomena concerned. Thus equipped, and with an appropriate terminology, we are now able to establish a proper scientific (bio-economic) method of biological interpretation. So far as competition alone is concerned, just as it has been found convenient for the practical purposes of medicine (and indeed of life) to distinguish between hundreds of maladies, so it is important for practical biological and sociological purposes to distinguish between the varied forms of biological antagonism existing in Nature. Only so shall we bring order (cosmos) out of the present biological and sociological chaos and arrive at a fuller appreciation of the Laws of Life than has yet been possible.

We shall now also be able to meet the burning inquiry which at the present time animates the whole civilised world, viz., What *is* the biological law? by pointing to the law of Symbiogenesis, and demonstrating that the laws of competition and of "battle" are but alternatives to that of Symbiogenesis.

If this recognition entails emancipation from an ambiguous, outworn and impeding metaphor which, moreover, carries far too many meanings to describe adequately what is sought to be represented (or what Biology should represent), the world will be the better for such emancipation. The sooner we discard "The Struggle for Existence" (and with it "Natural Selection") from all scientific disquisitions, the better:—

Der Mohr hat seine Schuldigkeit gethan
Der Mohr kann gehn.

Bald Darwinism as once understood does not, as we have already seen, stand alone in its failure to account for the

ethical and bio-economic problems of evolution, and in failing to elucidate the "slippery basis of metabolism"—most dreaded of all biological problems.

We can discover the same pathetic discomfiture even in quite recent writings of another school. Thus we find a great and sympathetic scientist, who for a generation has given himself up lovingly to the study of insect-life, bringing to light its manifold wonders, the veteran, Henri Favre, now happily of world-fame, disconsolately exclaiming:—"I am haunted by a gloomy thought: the weal of one means the woe of another." He speaks of *aspera fata*, of the stupid and ferocious law (?) that sacrifices a worker for the idler's benefit. "What have we done, we and the insects, to be ground with sovran indifference under the millstone of such wretchedness? Oh, terrible, what heart-rending questions the mason-bee's misfortunes would bring to my lips if I gave free scope to my sombre thoughts." Thus Henri Favre, moved by his contemplation of the "Tribulations of the Mason Bee," the Chalicodoma of the walls, a mason-bee who builds on the stone or pebbles and who, according to him, "may fairly boast of being an industrious workwoman." He pronounces a kind of "lasciate ogni speranza voi ch'entrate" on the mere consideration of parasitism. "I should be reduced to the gloomy lucubrations of a Schopenhauer if I once let myself begin on parasitism" (*English Review*, Sept., 1914).

Favre, who otherwise cheerfully informs us that among the mason-bees themselves right is might, is thus at one with the majority of evolutionists in leaving bio-economic problems well alone.

Und der Mensch versuche die Götter nicht,
Und begehre nimmer und nimmer zu schauen,
Was sie gnädig bedecken mit Nacht und Grauen.

But will the human spirit for ever remain satisfied with such admissions of incompetence? Will it not boldly challenge the doctrine that seems to involve such direful conclusions? I feel sure that it will, and I hope I have indicated the path of successful attack.

And thus we have found indeed much justification for Butler's remark that as soon as the world began to busy itself with evolution it said good-bye to common-sense. In the case of Darwinism, the ensuing uncommon sense has actually succeeded in rendering it plausible that parasites, though perhaps "otiose," yet represented the "fittest." (Could any theory have well been devised more calculated to encourage indulgence, selfishness, callousness and disregard or indifference as regards moral, not to speak of bio-moral, *i.e.*, cosmic, obligations?)

No wonder men like Virchow—pathologist and democrat—objected to the teaching of Darwinism in the State schools, and to the clandestine poison it has unfortunately to offer along with much that must pass as true and beautiful.

How much more have education and democracy to this day to gain from poor and ill-famed Jean Jacques—sincere friend and emancipator of the people! Rousseau—der aus Christen Menschen wirbt! (Schiller).

In the *Emile* he anticipates the great value of hygiene, and he warns instructors and teachers that—

La seule partie utile de la médecine est l'hygiène; encore l'hygiène est-elle moins une science qu'une vertu. La tempérance et le travail sont les deux vrais médecines de l'homme: le travail aiguise son appétit, et la tempérance l'empêche d'en abuser.

Thus the importance of the physiological factor was strongly present to his mind. He also gives reasons and examples of the superiority both physically and ethically of a simple natural (cross-feeding) dietary, observations which, as he says, are "de tous les lieux" and "de tous les temps."

Voltaire pronounced *Emile* a stupid romance, but admitted that it contained fifty pages which he would have bound in morocco. These, says John Morley, we may be sure, concerned religion. "In truth it was the Savoyard Vicar's profession of faith which stirred France far more than the upbringing of the natural man in things temporal."

In my opinion future generations will give pride of place to the physiological verities contained in the *Emile*, in

particular to those borrowed from Pythagorean wisdom which Rousseau approvingly though apologetically has taken from Plutarch's writings on Pythagoras.

Need I at the present day apologise with Jean Jacques for finding myself in agreement with many of these humane, wise, scientifically valid and truly eugenic thoughts uttered thousands of years ago by one of the noblest types of the human race, of whom it was said in antiquity that "a greater good never came, nor ever will come, to man than that which was imparted by the gods through Pythagoras." It was said of Rousseau that a new world begins with him (Goëthe); that largely owing to him in religion love has been substituted for fear; in politics people have begun to understand that the government of nations should no longer remain what for thousands of years it has been—the work of an absolute or arbitrary will; that in its place must be put the free government of the people by the people. "Wherever discipline has become more liberal, and the dignity of humanity is respected, there we may say Rousseau has passed by" (Dr. Charles W. Eliot, late President of Harvard University). The *Emile*, according to John Morley, was the charter of youthful deliverance. How much greater is the claim of Rousseau's master Pythagoras to have worked towards the indispensable physiological emancipation of man? Although this is as yet far from being as adequately recognised in modern times as it was in antiquity, I venture to think that I need not fear the "mauvais gré" of my readers for approving with Plutarch and Rousseau of the eugenic views of Pythagoras. The world has indeed become more tolerant since Rousseau's days. "Science" has returned to modesty since the days of Huxley, and Theology likewise—purified by the very opposition from the scientific camp—is more open to listen to new tidings calculated to deepen its foundations. Both Science and Theology may now be said to be open to new thought along their respective paths, and less bent on mutual condemnations and excommunications. It is necessary that this spirit shall grow further and expand into a veritable

symbiogenesis—some degree of opposition (competition) remaining merely to maintain their respective efficiencies.

In this spirit of reconciliation it must be granted—in spite of excesses committed by intolerant religionists of all ages—that the great world-religions have been of immense evolutionary value by laying down dietetic and hygienic rules for their adherents to obey. Nor has Science been able to supersede their teaching; but, on the contrary, it marvels more every day at the wisdom of ancient hygienic commandments, and it is at its best wherever it follows the path of hygiene.

When all this is said, I do not think that I need to apologise for anything said in these pages concerning the principle of physiological righteousness. More fitting is it for him on whom has fallen the privilege of furthering, to however slight a degree, the uplifting work of the early pioneers of humanity and illuminating again the paths which they indicated and to some extent explored, though equipped with far less powerful apparatus, to take courage from their leadership and the mighty consensus of noble thought in the past, to assert with a firm if modest confidence the principles for which he like them stands, and to use his every endeavour to support the cause of human progress which he like them has ever at heart.

“Wer den Besten seiner Zeit genug gethan,
Der hat gelebt für alle Zeiten.”

In this spirit Schiller and Goethe laboured for immortal victories of peace. This also was the spirit of Ruskin who prized loyalty so highly—loyalty still the same, whether it win or lose the game—loyalty to the highest that is in you. It is the same spirit in which, according to Huxley and Butler, the true man of science labours, and which animated Spencer when he used the splendid words: “The highest truth he sees he will fearlessly utter; knowing that let what may come of it, he is thus playing his right part in the world—knowing that if he can effect the change he aimed at—well; if not—well also; though not so well.”

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