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From

Edward W. Payson.

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THE SATURDAY LECTURES,

DELIVERED IN THE

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UNDER THE AUSPICES OF THE

Anthropological and Biological Societies

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INTRODUCTORY ADDRESS

BY J. W. POWELL,

Director, U. S. Geological Survey.

On the occasion of the delivery of the first of the Saturday Lectures, the following remarks were made by Major J. W. POWELL:

For many years the General Government has been prosecuting scientific research through various agencies. The field of these investigations is wide.

For a long time geological surveys have existed in various forms. In the study of the structure of the earth's crust—the mountains and plains, the hills and valleys have been traversed, and rocks, minerals and fossils collected; and by these fossils we come to a knowledge of the way in which the ancient earth was clothed with vegetation, and of the animals that lived in the ancient seas, lakes, and rivers, and roamed over the lands.

During all these years biologists have been at work studying the plants and animals that now live upon the earth and collecting biologic materials from every land.

During all these years anthropologists have been at work studying the native races of America and collecting their works of art.

Since the foundation of the Smithsonian Institution, it also has in all these departments promoted research and collected scientific materials for study, enlisting in its corps of collaborators men of every part of the United States—yes, of every land and every clime.

Since the organization of the Fish Commission, the nations of the seas, and the tribes of the lakes and the rivers, have been studied. Through these agencies, and yet many others, there has accumulated in Washington, in the custody of the Smithsonian Institution, a large body of material which has been the basis of a vast system of scientific research and publication. The General Government is now annually publishing from 20 to 50 large volumes—the monographs and memoirs of scientific research—and the rate of publication is rapidly increasing.

These materials have already performed an important purpose—greater than can be estimated, but their value is perennial.

With every advance made in science the old material must be re-examined for new facts, and to discover new relations. In this manner all are to go on increasing in value from decade to decade with the advance in human knowledge. In future years the scientific men of the world must resort to the National Museum at Washington, to pursue or to complete their studies. It was, therefore, the part of wisdom for the National Legislature to provide means for the preservation of this great collection, and to provide also, for its re-examination and increase.

These materials are not alone of interest to the scientific specialist. They have an interest and value to all intelligent people under whose eyes they fall—a value that depends largely on their orderly arrangement and classification; so that the great facts and principles of the many sciences represented, may be presented in birds-eye views to inquiring students.

Such are the functions of the National Museum, and the Institution is destined to exert an ever-increasing influence in the progress of science.

In order that all possible benefits may accrue from the enterprise it is proposed to establish a series of popular science lectures in this hall. Here, then, are presented the simpler lessons taught by the works of nature.

It is no easy task to explain the subject-matter of the various branches of science in such a manner that facts and principles may be easily grasped by those who are not specialists. A clear comprehension of any scientific subject is always accompanied by a power to clearly present the subject to scholars in the same department. A failure to present science to scientific men is fundamental evidence of failure in comprehension. But to present a scientific subject to those who are themselves not specialists or scholars in the specific department in such manner that they will be interested and instructed is no easy task. The man with this power, with this genius, is rare. He must be ready with illustration, apt in the selection of non-technical words, clear and forcible in his presentation, and especially must he be devoid of that pedantry which loves to revel in a wealth of details and technicalities, and he must so master his subject as to be thoroughly saturated with it. Then every word, every tone, and every gesture, will convey a thought.

The course is inaugurated this afternoon by a lecture on Scientific and Popular views of Nature Contrasted.

Since man first inhabited the earth, two methods of thought have

existed side by side—two ways of explaining things. In the Rocky Mountains you may hear an Indian explain the rainbow with all its beautiful colors as the serpent that abrades the firmament of ice to give us snow in Winter and rain in Summer. He sees its coil, he sees its stripes, he sees it against the sky of ice, and he sees it associated with rain which falls from above, and so he calls it the Great Serpent of the Storm. The method of thought by which he arrives at this conclusion is subjective and superficial analogies are used as the basis of conclusions. The man of science sees in the rainbow the analysis of white light into its constituent colors.

The method of thought is objective, and essential homologies are used as the basis of his explanation. But these two methods of thought appear in all stages of civilization and among all peoples. Subjective thought and analogic reasoning appear on the one hand, objective thought and homologic reasoning on the other: and it thus happens that in all the domain of Nature there is a vast body of phenomena that receives two explanations—a popular and a scientific. But, gradually, the scientific method is becoming the popular method, and scientific methods are being accepted and understood more and more, as the years pass, by the intelligent people of civilization; and it is the purpose of the lectures inaugurated this day to bring popular and scientific thought into harmony. Such is the task Professor Gill proposes for himself. May he abundantly succeed.

Ladies and gentlemen: I have the honor to present the learned and eloquent lecturer, Professor Gill.

SCIENTIFIC AND POPULAR VIEWS OF NATURE CONTRASTED.

Lecture delivered in the National Museum, Washington, D. C., March 11, 1882,
by Prof. THEO. GILL.

LADIES AND GENTLEMEN :

I feel loth to commence my lecture after the flattering introduction of Major Powell, for he has led you to expect more than you will receive, and to believe that what you receive will be adorned with the graces of oratory ; but this, I assure you, will not be the case. At the outset, I shall be obliged to explain as to the title of the lecture of the afternoon. A title had to be given, and that title had to be pithy. Exactly what ground is to be covered is not, however, evident from it. What I do propose is to treat of a very limited field, and in a very plain and conversational manner discourse concerning those relations which exist between certain groups of animals, and the opposite phases under which they are contemplated by the scientific mind on the one hand, and by the popular mind on the other. In doing this I shall take concrete examples, and, after considering the animals adduced, derive from the facts presented some deductions which appear to be legitimate. I will now only anticipate by the statement that the dictum, which is so prevalent in morals and social life—not to trust to appearances—is equally true for and applicable to the animal and vegetable kingdoms. The popular mind instinctively classifies animals according to external manifestations and adaptations, and especially with reference to the elements in which they live, be it earth, water, or air. This system of classification is, perhaps, almost coeval with the intellectual history of our race. Over eighteen centuries ago Ovid, the Latin poet, gave expression to such ideas in the first book of his *Metamorphoses* which I beg to recall to you in Dryden's version :

“ Before the seas and this terrestrial ball,
And heaven's high canopy that covers all,
One was the face of nature ; if a face :
Rather a rude and undigested mass :

No sun was lighted up the world to view,
 No moon did yet her blunted hours renew,
 Nor yet was earth suspended in the sky,
 Nor poised, did on her own foundation lie.
 Nor seas about the shores their arms had thrown
 But earth, and air, and water were in one.
 Thus air was void of light, and earth unstable,
 And water's dark abyss unnavigable.
 No certain form on any was impress'd:
 All were confusion, and each disturb'd the rest.
 For hot and cold were in one body fix'd,
 And soft with hard, and light with heavy, mix'd
 Thus dis-embroil'd, they take their proper place;
 The next of kin contiguously embrace;
 And foes are sunder'd by a larger space.
 The force of fire ascended first on high,
 And took its dwelling in the vaulted sky:
 Then air succeeds, in lightness next to fire,
 Whose atoms from unactive earth retire."*

As to the mode in which the various elements were
 peopled, hear also Ovid:

" Then, every void of nature to supply,
 With forms of Gods he fills the vacant sky;
 New herds of beasts he sends the plains to share;
 New colonies of birds to people air;
 And to their oozy beds the finny fish repair.
 A creature of a more exalted kind
 Was wanting yet, and then was man designed."

In such words the great poet has embodied the popular
 conception of the divisions of nature and of the relations
 thereto of the animals which people the world—one set for
 the earth, a different creation for the land, and a third for
 the air. These views, or some not essentially differing, were
 current until within a comparatively recent period.

It is easy by a merely superficial examination to convince

*Ante mare et tellus, et, quod tegit omnia, cælum,
 Unus erat toto naturæ vultus in orbe,
 Quem dixere Chaos; rudis indigestaque moles;

Hanc Deus et melior litem natura diremit;
 Nam cælo terras, et terris abseidit undas;

Neu regio foret ulla suis animantibus orba;
 Astra tenent cæleste solum, formæque deorum;
 Cesserunt nitidis habitandæ piscibus undæ;
 Terra feras cepit; volucres agitabilis œræ.

—Ovid Met. I, l. 5-7, 21-22, 72-75.

ourselves that this tripartite division of animal life is very incorrect. We see prominent about us, it is true, certain animals that seem especially adapted to specific elements—the quadrupeds for the land, the birds for the air, and fishes for the water; but as soon as we proceed to a more detailed review, and attempt to collocate with them the other animals that live on the earth we come upon stumbling-blocks in every direction and are soon forced to modify and change our ideas. Without taking into account the hosts of lower animals, naturalists soon recognized that even the vertebrates could not be combined under the tripartite division. Linnaeus gave the name *Amphibia* to those forms intermediate between the land animals and the water animals, including the reptiles and batrachians—frogs, salamanders, &c. But it was not till a long time afterwards that even Linnaeus became convinced that this was not going far enough. Only in the later editions of his work published toward the end of his life did he teach that animals must needs be regrouped, and in a manner that would be foreign to popular opinion. He first clearly recognized that whales were not fishes, but essentially agreed with the viviparous hairy quadrupeds, and under the name of *Mammalia* he first combined the two types in one class. I presume that the major portion of my audience recognize in a sort of way the fact that whales are not fishes, but mammals, or animals, as most people please to call them. At the same time there is a fear that many accept the dictum without understanding the why and wherefore they are so considered. It will, therefore, be my task this afternoon to give some of the reasons why the whales are not regarded as fishes, and why they are considered to be mammals. Afterwards it will appear that, by parity of reasoning, there will flow a series of deductions, applicable not only to the forms about to be treated of, but also to animated nature generally.

I doubt not that if the question “are whales fishes?” were put to popular vote, there would be an overwhelming assent to the ancient belief. Indeed the proposition that such is the case has been sanctioned by that “bulwark of

our institutions"—a jury in a court of law. About sixty years ago, a case was brought up in the New York courts, involving that question. It was a revenue case, and the suitor was one Maurice Judd. It was decided with all the formality of law that the whale was a fish! Times and ideas have changed since then, but not so much as to forbid us to believe that essentially the same views are prevalent at the present day, and I presume that the old verdict expressed the opinion of the majority of mankind at this time. Indeed, it may seem presumptuous in me to differ from such high authority as a court of law.

But without further preface, I shall now invite your consideration of the skeletons at my side, one of a porpoise, which is simply a kind of a whale, and the other of a swordfish, which is a true fish. I will contrast the differences between the two; first, as they appear in the flesh, and then those which become manifest on dissection.

As to form: of course, superficially there is a great deal of resemblance between a whale and an ordinary fish, and it is this superficial resemblance which has impressed upon the popular mind the idea that the whale is a fish. But, even if we consider only this external form closely, we find that material differences occur, and those differences are the indications of very much greater dissimilarity of anatomical structure. In the fish, the tail, you will see, is vertical; in the cetaceans it is horizontal.

In the skeleton of the fish, the tail is composed of many bones diverging from the tail vertebræ, and forming a framework for the vertical fin. The fish in its progress through the water moves this fin to and fro, sideways. In the skeleton of the cetacean, there are no bones in the tail, but the vertebræ taper backward, and have nothing comparable to the bones of the fish. The fin is represented simply by a mass of fibrous tissue and muscles, and it is inserted horizontally, so that the animal, in progressing, propels its tail upward and downward.

These are the indices of very important differences. The whale's tail is not at all like the fish's tail. The latter is a

peculiar organ, inserted at the end of the vertebral column, and has a frame work of bones, developed around the last vertebrae, and appended to them.

Before proceeding further to discuss the character of the caudal fin of a whale, let me call your attention to the fins which are developed under the belly or middle of the body in the carp and trout, and although absent in the sword-fish, in ordinary fishes present. You will find nothing corresponding to these in position in the whales, but I will now attempt to show that these fins, which are called ventral fins, inserted under the back, far forward, are represented by the flukes of the tail of the whale, which must, therefore, be entirely different from the tail of a true fish. But how can this be?

You are all acquainted with the external appearance of the seal, in which the posterior feet are obviously present, but are thrown far backward, and are to a great extent horizontal beyond the body. Now, imagine these fins, flippers, or feet, whatever you may call them, with the bones atrophied, or greatly decreased in size, and the integuments and soft tissues greatly hypertrophied, that is, enlarged, and you will see that no great difference exists between such fins horizontally extended backward, and the flukes of the whale. In fact, it is known, not only from anatomical, but from embryological and paleontological data, that the tail of a whale is essentially the result of an excessive development of the integuments surrounding the posterior feet, and the atrophy, or diminution of, or even in some cases the entire loss of the posterior limbs, so far as the bones are concerned. But the bones of the posterior limbs are not absent, or even insignificant, in all species of whales. In the right whale (that whence the whalebone is derived) we have not only the pelvic or haunch bones, but also the proximal bones—those next to the pelvic—developed; that is, we have not only the bones representing those which constitute the pelvis in man, but we also have other bones connected with these bones which represent the femur or thigh bone, and the succeeding or leg bones. Those bones are developed still more in

certain forms that are in some measure intermediate between the cetaceous and ordinary quadrupeds; that is, in extinct forms known under the name of Zeuglodonts which have not existed since the eocene epoch, and in ancient forms of the group, (Sirenians,) to which the Manatee, and the Dugong of the present time belong.

Reverting now to the ventral fins of the fishes, you will perceive that they correspond in position with the hind legs of tadpoles. If we compare the ventral fins of certain fishes of a very generalized kind, as it is called—that is, like those forms from which other fishes and amphibians are supposed to have alike descended—with certain extinct amphibians, also of a generalized kind we are prepared to recognize a similarity, and ultimately an equivalency of those ventral fins with the hind feet of quadrupeds. (The equivalency, let me state here, is called homology.) The so-called generalized fish which is most instructive in its indications is the *Polypterus*, (there is no common English name,) of the Nile, and other African rivers. The generalized amphibians are known as Labyrinthodonts, etc.

You will, I think, have no hesitation in recognizing the expanded vertical membrane of the tail of the tadpole as equivalent, so far as use is concerned, at least, with the tail or caudal fin of the fish. Let me further direct your attention to the fact, that the fish's tail and the tadpole's tail is median as well as vertical. If you are now prepared to concede all the propositions enunciated, you will be prepared likewise to give assent to the proposition, that the whale's flukes in horizontal position, and in being paired, are more like the seal's flippers, and therefore comparable with the hind limbs; and therefore unlike the tail of a fish. Inasmuch, further, as the seal's flippers are modified hind legs, and the ventral fins are also representatives of the hind legs, the whale's flukes are also modified hind limbs, and therefore the flukes and the ventral fins are equivalent, in a homological sense, to each other.

But how about the fore fins or pectoral feet? Are not they much alike in whales and true fishes?

Externally, the pectoral fins do look at first sight very much alike, but you will on looking closer perceive that as in the tail fin, the fish's pectoral has rays visible externally connected by a thin membrane, while none such are visible in the whale's fin.

On taking the flesh from these pectoral fins, and laying bare the bones, you will at once perceive how utterly unlike the framework of the limbs are in our two types—the porpoise and the swordfish.

In the porpoise we have not the least difficulty in at once recognizing the bones corresponding to the finger bones and metacarpal bones of man and quadrupeds; next we also plainly see bones answering to the carpal or wrist bones; then there are two bones evidently comparable with the bones of the forearm, that is, the radius and ulna; and finally, next to the body, we see a single bone which is plainly the equivalent of the arm-bone or humerus of man. Connected with the arm we find a wide flat bone above, and this, it is easily perceived, answers to the scapula or shoulder blade. Unlike then as the pectoral fin of a whale seems to be externally to the fore limb of man or quadrupeds, it is very much alike in the skeleton.

Now, let us turn to the fish's pectoral fin and its connections, and see how different they are from the whale's. Let us take a salmon's fin and compare it, or rather contrast it with the whale's. In the salmon, far from finding great similarity between its parts and the porpoise's, we meet with great difficulty in seeing any approximate agreement even: fin rays are first noticeable which are quite unlike digits or finger bones; at their base are four longish and nearly parallel but diverging bones, which remind us somewhat of metacarpals, and serve as a sort of peduncle to the fin. Next we find a chain of bones extending from the sides of the skull behind, and uniting below with its fellow of the opposite side: the pair are known as the shoulder girdle, or scapular arch; and remind us somewhat of the wish-bone or clavicles of a fowl. To the inside of the largest of these bones we see attached three bones, which intervene be-

tween it and the quasi-pedunculated fin. What are these, and how are they comparable with the anterior members and appendages of a whale? I am compelled to admit at once that we cannot compare them directly, and if we attempted to do so, we would almost inevitably fall into gross error; indeed, the old anatomists who made the attempt did so. Men, illustrious in science, like Cuvier, Agassiz, and Owen, considered the four longish bones we have noticed as carpals, and the two externally flattish bones which support them as the radius and ulna. To ascertain their true nature, we have to avail ourselves of extraneous evidence. I am, therefore, compelled, in justice to you as well as to myself, to make a slight digression.

Let us now examine for a moment the skeleton of *polypterus*, to which we have before referred.

The pectoral fin of *polypterus* has rays which are essentially similar to those of the salmon, and at the base of those rays are a number of nearly parallel longish bones which resemble the four at the base of the rays in the salmon. In *polypterus* we also find a shoulder girdle which is not unlike that of the trout. But now please direct your attention to the inner side of the principal bone of that girdle and instead of three bones, as in the salmon, you will find there is a single large piece; that piece has a peculiar kind of projection which is divided by a partial constriction from the body of the bone and reminds one of a ball. Articulating with this are two long diverging processes. Between these processes is to be especially observed a flat cartilaginous mass which also intervenes between them and the parallel longish bones.

To understand the structure thus revealed, examine now the pectoral fin and shoulder girdle of the common gar-pike of the Potomac river—the *lepidosteus osseus* of naturalists. The fin has rays like those of the *polypterus* and salmon; it has also the longish bones at the base. The shoulder girdle is developed as in them, but with special characters of its own. But the inner piece attached to the chief bone of the girdle is especially noteworthy. As in the *polypterus*, it is

single, but it otherwise resembles the three bones combined of the salmon, and the three elements of that type evidently are the disintegrated representatives of the solid cartilage of the gar. Note also that two diverging cartilages partly bound and partly intervene between the basal bones and the pectoral fin and cartilaginous pieces just described. If now, time and the occasion permitted, I might submit to you other forms, but I trust I have adduced sufficient to render it possible for your judgments to accept the following propositions as at least not improbable.

The pectoral fin and sustaining arch of the fishes in its several elements are referable to two categories.

The rays, the longish bones at their bases, and the bones or cartilages that bound or inclose them must be considered as the equivalents of the fore limb of quadrupeds.

The shoulder girdle is to be considered as representing the scapula of land animals, but with certain additions.

The projecting ball-like tubercle of *polypterus* is of especial significance.

Look, now, at the pectoral fin of *polypterus*, and compare it with the fore limb of a quadruped: you can appreciate some resemblance, I think, between (1) the diverging processes thereof and radius and ulna. (2) The wrist or carpus may be formed out of the included and succeeding cartilage of *polypterus*. (3) The metacarpals are at least simulated by the longish parallel bones at the base of the rays. (4) The phalanges may be represented by the pectoral rays. The humerus is still to be accounted for, and I am inclined to believe that it is represented by the constricted peduncle that supports the first named bones. Whether the relations thus indicated are true homological expressions has to be still proved, but they are, I venture to think, probable. But the very doubt still involving the question is, at least, one of the most cogent evidences of the great gap between the whales and the fishes.

If I am right in the conjectures thus adduced you will now see that while the fore limb, bone for bone, is the same in the whale as in the quadruped, it is only partially repre-

sented in the fish, the digits being probably, but only very distantly, repeated in the salmon by the rays, and the metacarpals by the bones at the base thereof; the bones of the arm—the radius and ulna as well as humerus—are entirely wanting. The single scapular or blade bone of the whale, on the other hand, is represented by at least four pieces, and connected with the arch of the fish are several other and accessory pieces.

I have thus dwelt upon the fins because if any part in the whale would show fish-like modifications, these parts would, from their relations to the surrounding medium, be naturally most liable to exhibit such adaptation. Upon the other points in the structure of the two types we cannot delay so long.

The shoulder girdle, as we have seen, is connected with the skull in the fishes, and let us take up the consideration of that next.

Look first at the whale's skeleton; note that the skull, as in man's, is one compact mass, composed of many bones, but all closely connected with their neighbors save the lower jaw. The lower jaw is directly articulated with the skull, and it is also especially to be noticed that its branches are undivided or single bones. Let me add as an item of information which I must ask you to take on trust that there are ear bones which, though much modified, agree essentially with those of quadrupeds.

Turn now to the fish's skull; you will at once perceive that the skull, contrasted with the mammal's, is much broken up. It has a brain box, but that does not at all represent the entire skull of the mammals. The upper jaw bones, the palate bones, and others, are separate. The lower jaw has each of its branches composed of four separable elements, and those branches, you will see, have no direct connection with the brain-box, but are separated by the intervention of a chain of large bones which are not to be seen at all in the whale's skull. But, nevertheless, those bones are represented in the whale's head, and the bones forming the suspensorium, as it is called, of the lower jaw have their repre-

sentatives in part in the ear bones of the cetaceous as of all other mammals.

Thus we find the same bones subservient to very different functions in the two types: in the mammal to hearing; in the fish serving chiefly for the connection of parts. The statement may evoke your skepticism, but I must ask you to accept it on trust, for time will not allow me to demonstrate its truth. I can only pledge myself that it has, I think, been clearly demonstrated that such is the case by the study of the comparative structure, and development of many forms, and by the collation of data derived from various types consecutively considered.

Connected with the skull you will perceive certain other bones or appendages. In the cetacean you may see pendant from the skull the articulation for the lower jaw, an apparatus composed of three bones on each side connected by a central one, reminding one somewhat of a pair of hooks or a card-rack. These bones are known as the hyoid. In the fish you will of course at once recognize the gills, which are on four arches on each side, but observe also another arch in front, and which performs the function of sustaining a membrane attached to the gill covers. Further observe that all these arches arise from a median row of bones to which the tongue is attached in front. Let me recall now a fact which you have doubtless heard of before—that even man as well as all other mammals have gilllets in the fetal stage of life, and of such gills the hyoid bones are the modified vestiges and reminders, and they roughly represent the gills and appendages which are developed so largely in the fishes.

Please direct your attention now to the organs which serve for the aeration of the blood in the cetacean, and to that which corresponds in the fish. You will notice that in the former there are lungs on each side, as well developed and as obviously lung-like as those of man, and that they are connected with the mouth by a tracheal tube which has anteriorly a thyroid apparatus, also as in man. On the other hand in the salmon there is nothing like a lung, but in its

place you will see an unpaired membranaceous air bladder, which is connected by a simple, narrow tube with the œsophagus, and in the swordfish, the tube, even, is entirely wanting, and the air bladder is shut off from communication with the mouth, direct or indirect. Nevertheless, did time permit, I could easily convince you that the lungs and air bladder graduate into each other, and that the two truly represent, or, in the language of the anatomist, are homologous with each other. On the one hand, our common gar has an air bladder so cellular as to be somewhat lung-like; *polypterus* has a still more lung-like bladder, and its relation to the intestinal canal, also approximates that of a lung; next a remarkable fish of Australia, named *ceratodus*, has what may more properly be called lungs than air bladder, and related forms of South America and Africa, known as Lepidosirenids, have as true lungs as amphibians. On the other hand, the amphibians, reptiles, and mammals show a gradation from the simple to the complex form manifest in the last.

Thus it will be apparent that the respiration of fishes and whales are effected by entirely different organs, and that the same organs may be modified and adapted for very different purposes. Nature is economical of her material, but most ingenious and versatile in the use of it, and employs the same stuff in many ways.

In connection with the respiratory apparatus we very naturally consider the heart, which receives the blood which has coursed through the body, and sends it to be purified and aerated by the respiratory process.

In the whale, the heart is partitioned into four cavities or chambers—a right auricle and a ventricle, and a left auricle and a ventricle—as in man. The right auricle receives the blood which has circulated through the veins, and the right ventricle transmits it to the lungs where it is oxygenated and thence goes bright and purified to the left auricle, and by the left ventricle is transmitted to again course through the vessels of the body. In the fish, the heart has only two chambers; an auricle collects the blood that

has nourished the body, a ventricle sends it to be vivified by the oxygen in the water, which moistens the gill filaments; from the gills it commences in a dorsal vessel a long course through the body, before again returning to the heart. The blood in the cetaceans is warm, in the fishes it is called cold. The differences which do exist have been generally exaggerated, however, and I only mention them because so much importance is popularly attached to them.

The important organs we have been last considering—the heart and the lungs—are inclosed in a special cavity of the chest, and separated by a partition or diaphragm from the other viscera, alike in the whales and other mammals. Heart and air bladder or lungs are far apart, and separated by—not from—other viscera in the fishes, and there is nothing like a diaphragm to partition off a special cavity for them.

We will next consider the brains of a whale and of a fish. They are entirely dissimilar. The brain of a whale is essentially the same as that of a man, and extremely different from that of a fish. I exhibit the brains of a porpoise and a man, and you can contrast them with the enlarged figure of the brain of a salmon.

These illustrations will give an adequate idea—at least so far as we are at present concerned—of the structure of all brains in the two widely separated classes comprising man and the whales on one hand, and the fishes on the other. Not only are the first two superficially essentially the same, but all the parts are readily comparable, and the closer you examine the more you will be struck by their similarity rather than their difference, when you take into account the differences in the form of the body. But compare with the brain of that, or any other cetacean, the brain of a fish, and the differences are very marked.

In the mammal brain the optic lobes are represented by small tubercles or lobe, while in the fish they are of preponderating development. The olfactory lobes and nerves are entirely concealed by the cerebrum and even almost wanting in the cetaceans, but they are very large, and ad-

vanced forwards in the fish. The cerebellum of the fish and cetacean have an entirely different structure, and as to differences of detail, they are innumerable.

Those parts which are concerned in the reproduction and perpetuation of the species, are equally noteworthy on account of the close resemblance between such parts in the whales and in viviparous quadrupeds on the one hand, and on the other, the differences from fish's. Their characteristics, however, we must pass over. Suffice it to say, that as in man, the whales are viviparous, and the young are nourished by milk secreted by the mother. But it is proper to add that such characteristics are of less importance than many others connected with the organs of reproduction.

Many fishes are also viviparous. Viviparity or oviparity is of minor value. It is the mode in which the eggs and young are developed that is most significant for the two classes.

Thus have we gone over the various parts of the economy of the whale and the fish, and in every case we have seen that the structure of the whale and man is very much alike, and that of the fishes very different.

If this superficial examination may be sufficient to convince us of the similarity of the whale and all other mammals, a more detailed examination would simply add force, and the cogency of cumulative evidence to the argument, and would still more impel belief.

Let us now take into consideration another set of facts. There are certain forms known as marsupials, represented in this country by the opossum. In Australia that order is largely developed, and is manifested in a number of different forms. There are, for example, species very much like wolves, others like mice, and they are so called by the Australian colonists. Now, if we considered simply external form, we should be compelled to separate those species from each other, and refer them to widely different groups. For example, we should have to take the mice-like marsupials, and approximate them to the true rats and mice, and the Tasmanian wolf we would have to approximate to the gen-

nine wolves and dogs. But a consideration of their anatomy—that is, of their brain, skull and its several parts, the hyoid apparatus, the pelvis, the bones of the feet, and the heart—in fact, all the parts of their organization—forces us to recognize that external form is of very little consequence in the appreciation of the relations of the animals, and that we are not only justified, but compelled, if we would express nature, to bring them together and keep them as the constituents of one natural group in contradistinction to all the other groups that are represented by forms which have a similar external appearance.

I need only remind you that every one now recognizes the bats as animals.

In brief, then, mammals may be described as animals which have no gills, which breathe by means of lungs, have a quadrilocular heart, sending the blood to the lungs, and receiving it thence and returning it to the rest of the body; a skull which has two condyles for articulation with the vertebral column and which has all its bones connected by suture with or contained in the brain case, except the lower jaw; and the lower jaw itself is comprised of simple branches which articulate directly with the brain case; the inner ear has three principal ear bones; the females are viviparous and the embryo developed from a very small egg.

In contrast, fishes can be characterized as animals which are branchiate or breath by means of gills, whose heart is bilocular, sending from one of its chambers the blood to the gills to be there aerated by contact with the water, which contains oxygen, and thence to the remaining portions of the body, to be in turn taken by the other cavity of the heart; the skull has an impaired median and circular articulation for the vertebral column; the upper jaw, palatine, and other bones are free from the brain case, and intervening between it and the lower jaw is a suspensorium of well-developed bones; the lower jaw is composed of several pieces: the females are oviparous or ovoviviparous.

Such are, in brief, a few of the distinctions between fishes and mammals.

The class of mammals contains forms fitted for progression on land, as bipeds (man) and quadrupeds; for flight in the air, as bats; and for exclusive life in the water, as whales.

The class of fishes comprises not only animals with the usual fish-like form exemplified in the salmon and perch, but broad flattened fishes like the angler or goose-fish, and others of snake-like form as the eels.

Mere form, then, is of no consequence in the determination of the major relations of animals and is of importance only in ascertaining the relations of minor groups. Every type of nature which we examine brings to us evidence of the truth of this proposition. Animals which have the greatest external resemblance may be, when anatomically considered, most unlike, and vice-versa, animals which are very different in external appearance, may exhibit great similarity in internal structure. I might adduce very numerous illustrations of the prevalence of this truth, but the advancing moments warn me that I must bring my remarks to a termination. I shall, therefore, conclude with certain deductions that are to be derived from the studies in which we have been engaged, and justify the title which I have selected for the discourse, by a contrast of the methods involved in the classification of the animals we have been examining.

The uninstructed observer instinctively considers animals with regard to their external form.

The naturalist has learned to distrust external form, and to consider internal structure as paramount.

The ordinary observer regards as of great moment the relation of an animal to its surroundings and mode of progress—whether in land, in water, or through air.

The zoologist has learned that the adaptations for different modes of life may coexist with slight differences in the internal economy.

Popular opinion inclines to the belief that physiology is the best guide to the classification of animals.

Science proclaims that physiology is the most delusive agent for the discovery of the true relations of organized beings.

In popular logic, again, deduction is the prime element involved. It is assumed that certain things are, and from this assumption the reasoner proceeds to approximate successively and without sufficient reason, the forms that are presented for examination.

In science, on the other hand, it is induction which is principally employed in mental processes; for example, we take a series of forms, compare them together, contrast all the elements of the several parts, and are guided by the detailed cumulative evidence of the marshalled facts.

The people use a nomenclature based on adaptations of parts for similar purposes, as the feet for walking, the wings for flight, the fins for swimming.

Science, while availing itself of the popular nomenclature to express one class of relationship—analogies—is compelled to resort to one of its own coining to express another set of relationships—homologies.

Now both of the words I have just used are constantly employed in scientific works, and all of you who have read such to any extent must have often come across them. But I trust to be pardoned if I explain their meaning, for it is impossible to begin to understand the problems of biology unless their signification is clearly apprehended.

Analogy is the adaptation of parts to similar functions but those parts may have no relation to each other nor be developed from the same parts of the body. The gills of the fish are analogous to the lungs of the whale, inasmuch as both are subservient to the office of respiration; but they are not homologous. The tail fin of the fish and the tail fin of the whale are also analogous, but they are not homologous.

Homology is similarity or repetition of structure, independent of the uses of the parts. The ventral fins of the fish,

the posterior limbs of ordinary quadrupeds, the legs of the human subject, the hind flippers of seals, and the caudal or tail fin of the whale are homologous. Several of the bones of the suspensorium of the lower jaw of the fishes and the ear bones of man are also homologous, although, be it remembered, they have no functions corresponding, being in that respect entirely dissimilar. Yet, again, homology is seen in the air-bladder of the fish and lungs of mammals; and, further, in the gills and branchiostegal bones of fish and the hyoid apparatus of man and other mammals. In all cases their functions are very dissimilar.

But do not infer that there is any necessary contrast between analogy and homology. Of course those parts which are formed of the same elements, and have the same functions, are both homologous *and* analogous.

It is by a strict attention to the principles thus expressed that natural history has attained its present high state, and we may, therefore be pardoned for believing that the tree of biological knowledge which has grown to its present height, and which is attaining maturity by attention to such measures is justified by its fruits.

But as the hour which we agreed to devote to our subject has been considerably exceeded, I shall not detain you longer, but, with thanks for your attention, retire from the platform.

WHAT IS ANTHROPOLOGY?

Lecture delivered in the National Museum, Washington, D. C., March 18, 1882,
by Prof. OTIS T. MASON.

LADIES AND GENTLEMEN:

The course of lectures now progressing in this hall has for its design the bringing about of a better understanding between scientific specialists and intelligent readers and thinkers. With this object clearly before me I shall endeavor, as well as my limited time will allow, to give such an explanation of Anthropology that my hearers will comprehend the extent and boundaries of its territory and the various operations which constitute its daily life.

The word anthropology, from *anthrōpos*, man; and *logos*, science, has run through a great variety of meanings, as those who have pursued it have shifted their ground or extended their researches. From 1501 to 1700 the word was used to signify "the study of the laws which govern the union between the body and the mind." In some theological seminaries it signifies "that manner of expression by which the inspired writers attribute human parts and passions to the Divine Being." In Dr. Hodge's "Theology," all that relates to man is called Anthropology. In 1772, Diderot and D'Alembert defined it as "a treatise upon man." In 1788, Kant wrote a work entitled "An Essay upon Anthropology." Latham in his "Natural Varieties of Man," (Lond. 1830, p. 559,) says, "Anthropology determines the relations of man to the other mammalia; ethnology, the relations of the different varieties of man to each other." In the schools of Germany up to a very few years, the term covered only what is included in the third sub-division of the subject given on page 5 of this lecture. Not so now. Paul Broca tells us "Anthropology has for its object the study of humanity in its entirety, in its details, and in its relation with the rest of nature."

Anthropology, therefore, while it excludes much that is human, includes whole territories of knowledge that are not

directly human. Biography, as such, is not anthropology, unless it connotes generic data. History, the biography of political societies, is only anthropological so far as it is not merely biographical.

Physicians were the first and are now the best anthropologists, yet not all in medicine belongs to the science. The same is true of every other profession and craft of men and women under the sun, each has in it a great deal that is not, but more that is anthropological.

Anthropology is the natural history of man in its widest sense. It embraces all that we mean by such terms as humanity, mankind, the human species, human nature. Nay, more. As we cannot study any species as a detached group, so we must include in our science all those natural objects, relations, forces, and facts, that have furnished the material, the impulse, or the limitation to human progress.

What human events and products are anthropological? I answer, those that are human, generic, tribal, capable of scrutiny over large areas, by statistics or by instruments of precision; whatever is customary, whatever can be shown to be a child of the past or a parent of the future. Eliminating those local eddies of thought and action which begin and end with the individual, and which constitute his biography, it takes notice only of those great currents of human phenomena that echo round the world. It therefore both *includes* and *excludes*,—includes, and day by day increasingly—all phenomena, material and psychical, related to the development of our race; excludes even human activities that are only the dust upon the mosaic of civilization.

By what methods does the anthropologist prosecute his work? I answer, by the most vigorous and exacting methods. By careful observation of multitudes of facts, by judicious discrimination of those marks which have true scientific value, by careful induction or classification, by cautious and modest deductions he plods his weary way.

Who may be an anthropologist? Every man, woman, and child that has sense and patience to observe, and that can honestly record the thing observed. There is not

another science that has not been maid of honor to this queen of sciences. If the rank of any branch of knowledge is to be judged by the intrinsic value of its object-matter, and by the number of other sciences ancillary to it, then anthropology must be advanced to the head of the line,—having no less a function than to explore the secrets of man's origin, progress, and destiny.

Having said thus much upon the scope and intension of anthropology, it becomes us to examine its sub-divisions, which represent especially the various classes of men engaged in its pursuit.

THE DIVISIONS OF ANTHROPOLOGY.

- I. The origin of man, inquiries into the time and the location of that event, as well as the natural processes involved, and his pristine condition. ANTHROPOGENY, (*Anthrōpos*, man, and *genēa*, descent.)
- II. The early history of the race. ARCHÆOLOGY, (*Archaios*, ancient, and *logos*, science.)
- III. The human species as a member of the animal kingdom. ANTHROPO-BIOLOGY, (*Bios*, life, the life history of mankind.)
- IV. The races of men, descriptive=ETHNOGRAPHY; deductive=ETHNOLOGY, (*Ethnos*, people, and *grapho*, to describe, or *logos*, science.)
- V. Mind in the lower animals and in man. PSYCHOLOGY, (*Psychē*, the soul, and *logos*, science.)
- VI. The origin, growth, and diversity of language. GLOSSOLOGY, (*Glōssa*, a tongue, and *logos*, science.)
- VII. The elaboration of human art and industries. TECHNOLOGY, (*Technē*, art, and *logos*, science.)
- VIII. Social structures and functions. SOCIOLOGY, (*Socius*, an associate, and *logos*, science.)

- IX. Beliefs and practices with reference to the spirit world.
COMPARATIVE MYTHOLOGY.
- X. The relations of the physical universe and social environment to human history. HEXIOLOGY, (*Hexis*, habit, and *logos*, science.)

By your permission I will now take up briefly these divisions and state, not what my own opinion may be, but the struggles and the difficulty which engage the students of anthropology the world over.

I.—*Anthropogeny.*

The great battle which has been fought with reference to the origin and the antiquity of the universe, is now being repeated with reference to the origin of man. As in astronomical observations each observer has his personal equation, which must ever be kept in view by those who would utilize his material, so into this discussion have men brought their theistic conceptions. We have, therefore, many theories of man's origination, a few of which I will give you.

- I. Special creation by Almighty fiat.
- II. Atheistic agnosticism, (*a* not, and *gnōsis*, knowledge,) denies the Creator, and affirms ignorance of man's origin.
- III. Theistic agnosticism. Affirms the Creator, but denies knowledge of the method of human origin.
- IV. Pantheism, (*pan* all, and *theos* god). God is all and all is God.
- V. Atheistic Darwinism. Denies the Deity and affirms natural selection as the cause of nature.
- VI. Theistic Darwinism, (God not immanent.) Affirms the Deity, but denies his constant presence.
- VII. Theistic Darwinism, (God immanent.) Affirms the Deity, and also his presence ever in his works.

VIII. Agnostic Darwinism. Affirms natural selection and ignorance of a Creator.

There are five distinct questions regarding the origin of man which nearly everybody confounds. They are as follows:

I. By which of the processes indicated above did the human species have its origin? Were they created, or did they descend from some ape-like ancestry.

II. When did that event take place? Was it six thousand years ago? Was it just on the hither verge of the latest geological epoch? Was it at the end of the glacial epoch, in its middle, or just before its beginning, or was it further back, at the beginning of the Tertiary that the first being worthy to be called a man appeared on earth? It would take far more than my hour to discuss this question of the antiquity of man alone, and, furthermore, I am not invited to discuss, but to define.

III. The third inquiry is, where did the first man alight upon this planet?

According to Moses and Haeckel, followed by nearly all modern anthropologists, our first parents lived somewhere near the Persian Gulf. But there is hardly a spot of the habitable globe that has not been looked upon as the favored birthplace of man. As no question in science is closed as yet, if anyone of my hearers is disposed to have his pet theory regarding this matter he will not be excommunicated so far as I am concerned.

IV. Bordering closely upon the last query, and affecting it, is the problem of the unity of the species. We are all aware that our distinguished countryman, Dr. Morton, followed by Agassiz and many others, held that our species had its origin, not in one, but in several creations. The weight of authority at the present time is in favor of a single origin. Professor Henry wrote, in 1866, "The spontaneous generation of either plants or animals, although a

legitimate subject of human inquiry, is as yet an unverified hypothesis. If, however, we assume that a living being will be spontaneously produced when all the physical conditions necessary to its existence are present, we must allow that in the case of man, with his complex and refined organization, the fortuitous assembly of the multiform conditions required for his appearance would be extremely rare, and from the doctrine of probabilities could scarcely occur more than at one time and at one place on this planet."

V. The last question concerning the origin of man is well represented in the controversy of Sir John Lubbock with Archbishop Whately. The former maintained that man was at first a low savage, and that the course of history has on the whole been a progress towards civilization. According to the latter, man has always been pretty much what he is at present.

II.—*Archæology.*

Bordering close upon anthropogeny is archæology, whose province it is to discuss the first efforts of the last child of nature to walk forth into the broad world. The data are far from complete, but are becoming more adequate to show the advance from rude stone to polished stone, to bronze, and finally to iron, as the material of human implements.

In this study the geologist, the linguist, the anatomist, technologist, and the sociologist meet to reconstruct priscan society. As the present epoch epitomizes all preceding epochs of the world in its fauna; so does the *ensemble* of humanity to-day comprehend all past histories. It is no more difficult to reconstruct an ancient tribe from a few human bones and implements than for the comparative anatomist to re-edify an extinct animal from a few of its fossil remains. I could give you no more convincing proof of what I say than to invite you to study carefully Professor Rau's archæological collection, in the Smithsonian Building.

III.—*Anthropo-Biology.*

So far as man resembles the living beings around him, reproduces his kind, grows from infancy to maturity, is amenable to the laws of material nature, dies and returns to inorganic matter, he is an animal. Again, a minute comparison of his body with that of animals shows a striking resemblance, if not genetic relationship. But my flitting hour would warn me from this tempting field even if I did not know that Dr. Fletcher's lecture would be devoted entirely to this division of anthropology.

IV.—*Ethnology.*

Thus far we have spoken of all mankind. We come now to inquire what notice anthropology takes of the varieties of men. At first thought you would say that it is the easiest matter in the world to distinguish a white man, a negro, an Indian, a Chinaman, and a brown Malay. As we were told in Dr. Gill's lecture, popular notions are altogether at fault. If we could stand all the men of the world in a row, it would be possible to arrange them in such a manner that you could not tell where one race left off, and another began, and yet students of art have always recognized race characters. Two thousand years before Christ, the Egyptian sculptors faithfully portrayed the Negro, the Semite, and the Egyptian countenance.

The same theories that have been relied on to explain the origin of man, have been invoked to explain the diverse races. By various gateways students have sought to enter the mystery,—by the color of the skin, the section and appearance of the hair, the facial angle, the ratio of the length to the width of the skull, the projection of the jaws, language, customs, beliefs, etc. Now I am sure that all present are too scientific to suppose for a moment that mere classifying is science. If I were to separate you by your dress, or facial beauty, or residence in the city, such arrangement would have no value whatever. A true scientific classification is based, first, on immutable attributes, and,

second, seeks to ascertain relations, affinities, and consanguinity. Linnæus (1741–1783) made four divisions of man, Blumenbach (1752–1840) established the five classes which are kept up in our geographies to this day. I should only weary you repeating catalogues of authors and their schemes of mankind. I give you a table by the latest authority^c Dr. Topinard, based on the hair, the skull, and the complexion, (Paul Topinard, *Revue d'Anthropologie*, 1878, p. 509.) It is very far from satisfactory, however, and the classification of mankind is still an open question.

Hair round in section, straight.	{	Dolichocephalic,* (long-heads.)		Eskimo.
		Brachycephalic, (short-heads.)	Red.	Red-Skins.
			Olive.	Mexicans and Peruvians.
			Yellow.	{ Guarani, Caribs. Samoyceces. Mongols, Malays.
Hair roundish in section; waved, frizzed.	{	Dolichocephalic, (long-heads.)	Blonde.	{ Cimmerians. Scandinavians. Anglo-Saxons.
			Brown.	{ Mediterraneans. Semites.
			Black.	{ Australians. Indo-Abyssinians.
		Brachycephalic, (short-heads.)	Red.	{ Foulbes. Red Barabras.
			Blonde.	{ Fins. Ceits, Slavs. Iranians.
			Chestnut	
Hair elliptical in section, woolly.	{	Dolichocephalic, (long-heads.)	Brown	
			Yellowish	Bushmen.
		Brachycephalic, (short-heads.)	Black.	{ Papuans. Caffres.
			Black.	Negritos.

* Dolichocephalic = *dolichos*, long, and *kephalē*, head; brachycephalic = *brachus*, short, and *kephalē*, head. The angle of the jaw gives rise to orthognathous = *orthos*, erect, and *gnathos*, jaw; and prognathous = *pro*, forward, and *gnathos*, jaw. See Topinard's "L'Anthropologie," Paris, 1876, pp. 254, 261, 299.

I may say, however, that Russia, Austria, Germany, France, England, and the United States have each organized special bureaus for the minute examination of the peoples within their limits.

V.—*Psychology.*

What has anthropology to do with metaphysics? Just two things. The science of metaphysics itself has had a history. Men did not always look upon the intellectual faculties as they do now. The evolution of psychological studies is certainly as interesting as the life history of any living thing. But, again, mind is born and grows: there are race psychologies as well as race anatomies: and the whole human intellect has had its progress by stages. Every mother before me, had she leisure from her burdened life, could write a most wonderful chapter in anthropology, by recording minutely, day by day, how a little child emerged from the chaos of ignorance and progressed in the unfolding of its mind by the acquisition of knowledge. I shall have spoken in vain if I have not clearly shown that the average history of the individual is the history of the race, and that this great giant of humanity took on ideas just as does the little child.

Again, brutes have minds. Anthropology is making the most exhaustive investigations into the question whether they differ from us in quality of mind or only in degree: whether the instincts of the brute are the parents of human thoughts. In this portion of the subject is involved the vexed inquiry whether the brain generates thought as the liver does bile; or whether there is a spirit in man which constitutes his true individuality, for which his body is only a temporary abiding place.

VI.—*Glossology.*

The department of anthropology which investigates language is variously termed, linguistics, philology, glossology, and the science of language. It has for its object to inquire

into the origin of language, and many hard-fought battles attest the energy with which the various champions have entered into the subject. Languages have changed and differentiated. How, and through what causes? They mix, and new languages arise. They have their anatomy and physiology. They have their purely physical side, being composed of muscular gestures and vocal utterances, purely physiological. They have their psychological side, "Sound is but the curtain behind which is concealed the mystery of thought." As before stated, the whole history of man is the unfolding of mind, and language thus becomes a historical science. The anthropologist does not stop with vocal speech. For him bodily attitudes, animal voices, the gestures of the dumb, and of lower races are language. We have in this very building a Bureau of Ethnology, where, under the direction of Major Powell, such specialists as Mallery, Dorsey, Gatschet, Hinman, and Riggs are wrestling with the American Indian languages. The same zeal characterizes the cultivated nations of Europe. The vocal and written speech of man is found to have kept pace with the progress of his thoughts.

The growth of language is spoken of as having passed through three stages, or as occurring in three fundamental types:—

1. The Holophrastic, (*holos*, whole, *phrasis*, phrase,) in which whole phrases or sentences were thrown into a single utterance; or polysynthetic (*polus*, much, and *synthesis*, compounding.)

2. Agglutinative, (*agglutino*, to fasten or glue to,) in which the words are much compounded, but only one of the word-elements retains the ancient forms, the others being pared down to mere appendages.

3. The Inflected, in which relations are indicated by endings, which no longer have any meaning, but serve merely to indicate the function of their stem. The whole subject is thoroughly and freshly worked up in Major Powell's "Introduction to the Study of Indian Languages," which I would advise you all to read.

The recording of speech, also, has had its peculiar and interesting course of life. Beginning with mere tally sticks, hunting and gambling scores, and such mnemotechnic devices, the student may carefully thread his way through rock-carving and picture writings to hieroglyphics. The abbreviation of hieroglyphic symbols to words and syllables, and even to sound symbols took place very slowly, but the process may be traced in the older and later Egyptian and Chaldean writings. The art of printing is the last stage in the journey of graphic representation. The study of Indian pictographs, as well as the sculptures of Mexico and Central America, promises to furnish some very important chapters in the history of linguistics.

VII.—*Technology.*

The portion of my subject in which most of my hearers are interested, however, is the evolution or the elaboration of industries, or comparative technology. As archaeology reveals the progress of invention in *time*, so technology reveals the diffusion of the grades of culture over the earth. The two are twin sisters of the operative or material side of anthropology. You cannot imagine the smile of satisfaction which stole over the face of a Patent Office friend when convinced that some of the most important materials of anthropology passed through his hands every day. He exclaimed, "I am an anthropologist! I thought I was only an examiner. I am going to write a paper on anthropology." There is not a phase of civilization that has not had its tools, its edifices, its paraphernalia. There is not a tool, or building, or garment, that has not passed through a series of transformations most interesting to trace. These objects may be looked upon as species in natural history. They cross and interlace so as to form the gorgeous tapestry of human culture.

To my lady friends I would say this subject is of thrilling interest. There is not a thing that you wear, or eat, or enjoy, that has not come down to you through a wonderful experience. The worship of the beautiful did not origi-

nate with Oxford students in the XIXth century. "Woman was the first potter and embroiderer. She is everywhere the primitive decorative artist, and it is the exception that man occupies himself with ornamental art, even in civilized countries. Woman covers with ornament everything her hand touches, and the lady in her boudoir industriously embroiders on some article of mere luxury, the same series of frets and scroll borders which, on the Amazonas, the savage, unclothed squaw as diligently, and with as firm a hand, traces with a spine on the damp surface of the clay she is fashioning." It is as if they sang the same simple song, like a silver thread binding all lovers of the beautiful into a common sisterhood. Could we find the missing links, the arts of Egypt, Assyria, Greece, and Rome would not stand out like green islands of the sea, but would form the necessary parts of one homogeneous structure.

The idea has seized the fruitful mind of Professor Goode, Assistant Director of this grand Museum, and you will read in Professor Baird's Circular No. 2, as follows :

In the new building will be concentrated all the industrial collections, and all the ethnological specimens, except the reserve series of pre-historic stone implements. In the old building will be kept those collections which are most important as material for purely scientific investigation, such as the main collection of birds, the fishes and reptiles in alcohol, the marine invertebrates, etc. The new building will, however, contain the collections in economic natural history.

The collections in the new building are intended to form an *Anthropological Museum*, organized upon the broadest and most liberal interpretation of the term "anthropology," and illustrating the characteristics of civilized as well as savage races of mankind and their attainments in civilization and culture. The central idea will be *man*, and the manner in which he adapts the products of the earth to his needs. All useful and noxious animals, plants, and minerals will be shown, industries by means of which they are utilized—by both method and finished product—and finally, the various objects which men use for any purpose, whatever. *A place is provided for every object which has a name.**

*At this point several series of objects were exhibited to the audience to illustrate the two ideas, *progress* and *adaptation*. Among them was the growth of the ship from the dugout through the skin boat (variety : birch-bark canoe) to the steamer Fish Hawk ; the evolution of the knife, the hammer, the bottle, the saddle, food, and ceramics.

VIII.—*Sociology.*

The next division of our subject is sociology. The history of civilization is really the history of society. Little do we think in our Christian homes, where one man and one woman through mutual love devote themselves to their offspring; in our well-ordered cities where life and property are protected and every convenience of public life furnished to rich and poor alike; in our grand nationalities and world-embracing exchanges, how humble and rude were the beginnings. We must go back to a gregarious state, where brothers and sisters intermarried, where the bond of union was fragile, where children belonged to the group, and there was no magistracy or public spirit. We thence pass upward to the Australians, in whose social system there is a quadruple classification of male and female for marriage and other purposes. The North American Indians furnish the next grade, with their curious clan organization, and descent in the female line.* Passing onward through semitic polygamy, we are brought to our own platform of social life in all its complexity. There are vast territories of knowledge, including ceremonial institutions, ethical codes, morality, and legislation, which I can only mention in this connection, but which have engrossed the greatest philosophers of the world in all ages.

I have prepared a chart in order to indicate to the eye how the progress and adaptations of culture in the various categories may have taken place. At the top are Morgan's seven periods, the second horizontal line gives a typical event of the period, the third, a representative race, taken at random, the succeeding lines refer to the categories of culture.

The whole subject is of commanding interest to the legislator and the student of history, but as we are to hear from Major Powell upon this topic, I pass to the next division, the Spirit World.

* The Rev. Owen Dorsey's charts of Dakota clans were exhibited in illustration.

CATEGORIES.	GRADES OF CULTURE.		
MORGAN'S SCHEME.....	Lower Savage.....	Middle Savage.....	Upper Savage.....
CHARACTERISTICS.....	No fire, rude stone.....	Fish diet, fire.....	Invention of the bow.....
RACE.....	St. Acheul.....	Australians.....	Nomadic Indians.....
FOOD.....	Raw products of the earth.	Indigenous products, roasted and stone-boiled food.	Dried meats and plants, dug-out vessels for cooking.
CLOTHING.....	None, or a wind shield.	Capes of skin or coarse matting.	Caps, body clothes, moccasins, of the sexes much alike.
HABITATIONS.....	Caves and shelters.....	Temporary huts and wind-breaks.	Tents and wigwams in clan-groups.
IMPLEMENTS.....	Palæolithic.....	Charred spears, hammers, knives, nets, dug-outs, fire-drills.	Skin-dressing, basket-weaving, bow-dressing.
WEAPONS.....	Clubs and stones.....	Spears, clubs, boomerangs, throw-sticks, shields.	Bows and arrows in great variety, scalping knives.
LOCOMOTION.....	No appliances.....	Trails and landmarks..	Snow-shoes, sledges, dug-outs, rafts, and skin-boats.
ÆSTHETIC PRODUCTS.....	Painted bodies, strings of shells, whistles and wooden drums.	Feathers and paint, gorgets and limb trappings, stick and skin drums.	Tattoo and paint, embroidery and fringes, rattles and bells.
DOMESTICATION.....	None.....	The dog.....	Dogs, ponies, deer. In the south, birds.
INDUSTRIES.....	Hunting and fishing...	Supplying wants, little division or barter.	Hunting, fishing, gathering, barter, wampum.
LANGUAGE.....	Interjectional and by signs.	Guttural, clicking, reduplicative.	Agglutinative, prone to dialectic change.
KNOWLEDGE.....	The habits of game, a little about the stars and the weather.	Count four, predict weather, judge locality and distance, name species.	Decimal notation, time, genera of objects, natural phenomena.
BELIEFS.....	Everything animated..	Ghosts, hero ancestors, animal soul in things.	Sorcery, future life like this, good and evil powers, myths.
WORSHIP.....	Appeasing everything.	Sorcery, rain-making, fetish worship.	Medicine pow-wow, invocation by smoke, fasting, mutilation.
MORALS.....	Conformity to clan use. No code.	Conjugal and parental duties not enforced, hospitable, improvident.	Chastity of wives enforced, generous, cruel.
SOCIAL STRUCTURE.....	Promiscuity.....	Punaluan marriage in groups.	Ganowanian marriage, mother-right, clan-system.
SOCIAL RITES.....	Not known.....	Marriage by capture, greetings formal, tabu, deposit burial.	Marriage rite weak, Potlatch feasts, burial various.

GRADES OF CULTURE.

Lower Barbarous.....	Middle Barbarous.....	Upper Barbarous.....	Civilized.
The art of pottery	Domestication, cereals.	Smelting, writing.....	Printing.
Iroquois, Muskoki.	Zuñeis, Aztecs.	Semitic Races.....	Later Aryan.
Food partly raised, corn, beans, &c. Drinks. Food boiled.	Tortillas, gruels, cacao, chile, intoxicants.	Porridge, milk, decoctions, leaven, metal dishes, fruit trees raised.	Every variety, animal and vegetable.
Shirt, apron, robe, leggings, mocassons, head-dress.	Varied with rank, highly ornamented, shoes.	Of cotton, linen, and woollen stuffs, varied with rank and occasion.	Differentiated for sex, rank, and occasion.
Long-houses and permanent villages.	Stone, adobe, lime, flat roofs, public buildings, no arch.	Sun-dried bricks, stone, wood, less communal, shops, arches, streets.	Strictly family, exceedingly varied, gas, water pipes.
Polished-stone, mortars, wood-working, pottery.	Digging-stick, clay working tools, mule trappings.	Herding, weaving, meal, and farming, rude handicraft.	Stimulation of invention by protection and patent laws.
Bow, club, tomahawk, scalping-knife, of better make.	Obsidian ax, spear, obsidian knife, darts, slings, shields.	Flint-jacks, wall and meat, sword and lance.	Fire arms perfected, iron clad, signal service, &c.
Canoes, litters, carrying places.	Canals, roads, causeways, bridges, llamas, and, later, mules and horses.	Beasts of burden, floats, open ships, camel trails.	Steam carriage added.
Paint and pendants, textile, stone, shell and feathers, flute of 10 notes, drums, rattles.	Paint and toggery, carving in stone and wood, embroidery, drums, shell-horns, flutes.	Jewelry and scents, massive structures, music varied, poetry ornate.	Architecture, sculpture, music, painting, heliographs.
Same as last. No others to domesticate.	Deer, rabbits, fish, many birds, cochineal.	Camel, cow, horse, dog, sheep, goat, poultry.	Every branch of the animal kingdom.
Taking from nature, raising crops, making utensils, exchange.	Weaving, felting, dyeing, stamping, ceramics, stone cutting.	Metallurgy, caravan and ship trade, markets, fairs.	Work in land, forest, mines, waters. Commerce.
More and softer sounds, holophrasms longer, wood and rock carvings.	Forty sounds, polysyntheticisms euphonic, symbolic writing.	Highly inflectional, writing syllabic or alphabetic, literature.	Inflected, writing, printing, telegraph.
Count 100, wampum in historic narration, the stars, use of medicine.	Vigesimal counting, calendar, natural history, medicine, maps.	Astronomy, geography, medicine, history, law.	Science, metaphysics, history, technology, politics.
Dreams, wandering ghosts, Great and Evil Spirit, minor deities and heroes.	Superstitions, Precognition, element worship, seven great gods.	Monotheistic or polytheistic anthropomorphism.	God, angels, spirits, future life, retribution, agnosticism, atheism.
Religious order separate, offerings, festivals, dances, nature worship.	Priestly caste, pantheon, human sacrifices, oaths, vows, fasts, penances.	Sacred books, preaching, prayer, fasting, ams, chants.	Public and private. The spirit above the form.
Labor degrading to men, dignified, kind to women and children, cruel.	Submissive, unchaste and drunkards punished, true, kind, chivalrous.	Temperate, lewd, polite, hospitable, shrewd, brave, treacherous.	To love God supremely and our neighbor as ourselves.
The same, father-right begins, and personal property.	The same, father-right, property more individualized.	Patriarchal family, polygamy, property in severalty, despotism.	Monogamic family, father-right, Free State.
Marriage by presents, ball games, ossuaries.	Marriage elaborate, games, ceremoniousness, attendants killed at the grave.	Harems, games, bathing, burial near shrines.	Marriage by priest, survivals of ceremony, burial in graves and tombs.

IX.—*Comparative Mythology.*

It is very difficult to find a word to cover exactly the ground which the anthropologist includes in the word religion. Among Christian people, the term is applied to certain beliefs, forms, and conduct; and the adjective, religious, would not be understood if applied to discussions merely; but let it pass.

There never was a people so rude as not to observe nature and to assign causes for everything that passed through the avenues of their senses. Into those causes life is projected and human or animal attributes added until a *philosophy* or *theology* is built up.

Secondly, in some form or other men early begin to believe in a future life, to people an unseen world with innumerable beings, good or bad, and to separate these beings into classes with functions. This forms a *creed*.

Further, certain actions on our part are due to these beings—will please, displease, or appease them. Men fast, chant, pray, dance, and sacrifice; they deny, weary, and mutilate themselves, for this purpose. They set apart a class to wait upon the gods, build costly edifices in their honor, in which the continual sacrifice and savory incense ever attest the fear, or the devotion of the worshippers. Among any people this constitutes their *cult*.

By the testimony of missionaries and others, who, like Mr. Cushing, have lived among a lowly people long enough to win their confidence, we are in possession of the facts which will enable us roughly to outline the world's theologies, creeds, and cults. The anthropologist, far from being shocked by the seeming absurdities of these lower forms of religion, beholds in them the germs of all our beliefs. I have frequently thought, while reading of the bloody and cruel fetish worship of the dark-skinned African, that a kind providence had effected the whitening of the human skin coordinately with the purifying of religious conceptions. At

any rate there has been progress in comeliness and improvement in religion.

At first, each individual thing was thought to be ensouled. A little after there were ghost-gods, which might be influenced by fetishes or incantations. Worship of things, places, animals, and plants follow in quick succession. Another step brings us to the deification of the powers of nature, under symbols, barbarous or chaste according to the taste of a people, which constitute the world's idolatries.

How pleasantly we might spend hours tracing through its mazy windings the conception of personal causation, from the gross forms of savage philosophy to that grand idea which traces all creative power and providential control to majestic law, "that has its seat in the bosom of God, and its voice is the harmony of the universe." With Major Powell, Mr. Cushing, Mr. Dorsey, and Mr. Hinman, we should sit down at the Indian's hearthstone and hear in their simple myths echoes of the childhood of the world. With Professor Anderson we should visit the prisæan home of the Anglo-Saxon race, and recline under the shadow of the tree Ygdrasil, at the feast of Tuiseo and Woden, Thor and Fria. Our survey could not omit Chaldaea, Assyria, Persia, India, China, or Egypt. Much more, the gods, the myths, the sculptured forms and world-surpassing temple architecture of Greece, and the pure monotheism, exalted poetry, and pathetic history of Judea would engross our serious thoughts. Rising above all, yet not contemptuous of any, at last would shine refulgent that undefiled Christianity which declares the fatherhood of God and the universal brotherhood of man.

X.—*Heriology.*

We come at last to speak of that chapter in anthropology which treats of the reciprocal actions of man and his environment. In every thing that comes to be what it is, there are two sets of forces at work, the internal and the external, the constructive and the destructive, the impell-

ing and the restraining. We see it in the sea and the shore, the breath of the glass-blower and the mould in which the bottle is formed, the vitality and the favorable or unfavorable location of the plant, the habitat and the vigor of animal species, and finally in the races of men and their inorganic and organic surroundings. The anthropologist has no more difficult problem before him than to ascertain the influence of climate, outlook, food, and social environment, to produce varieties in man, to set in motion that great current called "the migration of nations," and to bring about from nothing, all that constitutes the various civilizations of the world. Inasmuch as the poorest farmers buy the least productive lands, the sterile districts of a county even will be less cultured than the most fertile; and living upon such ground soon reacts upon the people, only to increase their poverty and to decrease their vitality. How much more, then, may we expect to find the abject races of man living in the suburbs of the world, where squalor is engendered by the surroundings, until there is a harmony or equilibrium between the unpropitious skies and their wretchedness. On the other hand, the contact, the rivalries, and even the bloody wars of favored races have awakened an emulation productive only of good.

It is the business of the anthropologist to trace out these subtle causes and influences which advance or retard civilization, which have covered the earth here with prosperity, there with melancholy ruins. So far from being beneath the consideration of the highest and most gifted intellects, this and not petty expedients should be the subject of serious inquiry by the statesman, the political economist, and the philanthropist.

My task is nearly finished. My object has been to define a science in which there is no priesthood and laity, no sacred language; but one in which you are all both the investigator and the investigated,—the judge, the jury, and the prisoner at the bar. I have endeavored to portray in outline the work of the anthropologist, so that you may intelligently follow my successors who will treat of special themes.

I shall not have spoken wholly in vain if I have indicated the lines of all social progress and led you to see, however faintly, the value and indissoluble union of the humblest human phenomena—

“ That nothing walks with aimless feet ;
That not one life will be destroyed,
Or cast as rubbish to the void,
When God hath made the pile complete.

That God which ever lives and loves,
One God, one law, one element,
And one far-off, divine event,
To which the whole creation moves.”

CONTRASTS OF THE APPALACHIAN MOUNTAINS.

Lecture delivered in the National Museum, Washington, D. C., March 25, 1882,
by Prof. J. W. CHICKERING, Jr.

Science pertains to that which is known, not that which is conjectured or guessed at. It is based on facts, and not on theories. A hypothesis may oftentimes be useful in scientific investigation—just as is the scaffolding in the erection of a building, it may even, at length, come to be built in, may become part of the temple of science, but then it has ceased to be a mere hypothesis, and has become itself a fact.

The science of to day, entitled to the name, rests upon a solid foundation of fact, is an induction, not a deduction.

Science, therefore, and especially advancing science, is omnivorous as regards facts. It is a veritable Gradgrind. "*Nihil facti alienum est a scientia.*"

One fact alone does not prove much. It may, if new, interest or surprise, but its chief value will be in its power to stimulate to the collection of other new and kindred facts.

"One swallow does not make a summer," but when the flock has arrived, and the nests are in process of building, we know the summer has come.

We need, therefore, first of all, a multitude of facts, and then we need to have them collated, compared, classified according to their resemblances and their contrasts. The observation of facts is, for a time, the first duty, the chief employment of the scientist. It precedes all else, all theories, all classification, all order.

To observe, and as far as may be to collect facts, are expeditions sent out, and thousands of observers at work. This Museum is, and is to be filled with concrete facts.

Now, fortunately many men are born fact-collectors, fact-mongers, with taste and aptitude for the pursuit of facts.

They are men who are ready to reply to ridicule or questioning, as did the astronomer to the query, why he was expending so much time, money and trouble, in endeavoring to rectify his computation of the distance from the sun to the earth.—“Because I want to know.”

These men are the advance guard of science, the pioneers, the original investigators, the sappers and miners of the scientific army.

All honor to those who have thus wrought, and are now working amid torrid heat and arctic cold, who have discovered the sources of the Nile, or sought the open Polar Sea, not a few of whom have sacrificed their lives to their labors.

But these facts must be interrogated, made to tell their story, and that the true one, or they are of but little worth, and the Museum is little more than an “Old Curiosity Shop,” a museum instead of a muséum.

It has been said that “figures cannot lie.” But I think few would admit the truth of that saying, on the eve of a popular election, as they read the opposing papers.

I think there have been even scientific discussions, in which the same facts were made to tell very different stories.

A master mind, capable of classifying and generalizing is needed to marshal these facts, to make them speak, to make them tell the truth.

Just as in this Museum we are beginning to see how order can be evolved out of confusion, and hope eventually to see classified and properly labeled facts on these shelves, telling us the story of man, his environment, and his achievements.

For while to one man a fact may be an ultimate thing,

“A primrose on the river’s brim
A simple primrose is to him.”

to another it suggests problems, inquiries, investigations.

Whatever progress has been made in science has been mainly due to the persistent asking of three questions: “What?” “How?” “Why?” and to the equally persistent attempt to answer them.

The man who takes no interest in these questions will never make a scientist.

When, then, we have been able, in a measure, to answer the question "What?" and have the facts before us in records or in museums, there presents itself to the scientific mind the second query, "How?" How came this to pass? What have been the processes? Can they be repeated or varied?

Here comes in, the so-called practical, economic application of scientific knowledge, the *use* of facts, nowhere more earnestly studied than in our own land.

The Museum calls into existence the Institute of Technology.

But while some are content to stop here, to others comes irresistibly the query, "Why?" What are the underlying principles? And the query divides itself into two—causal and teleological. What is the reason, the cause, the statement in terms of law? What is the object, the final result, the end to, or for which?

And here in this Smithsonian Institution are gathered men who are giving their lives to the answering of these questions.

The museum, with its facts, both in biology and anthropology, has rendered possible the two lectures to which we have already listened with so much of interest and profit.

Now, in this scientific army, it were well if we all were enrolled, according to our talents and our opportunities, and it is, I suppose, one object of this course to interest, if possible, all who attend, in scientific subjects; to instruct in scientific methods; to give information as to what has been done, and to suggest what remains to do.

I shall now attempt, in accordance with the principles thus enunciated, to state a few facts, possibly some of them new to some of you, to make a few generalizations, to suggest some things to be observed, and some results of observation among the Appalachians.

Out upon the watery waste of the Archean Ocean, as the Eozoic age was drawing to its close, looked here and there a

few scattered peaks, "*rari nantes in gurgite vasto*," outlining what we now call the Appalachian Mountain System.

It was at the time when, as we learn from the earliest written geological record, "God said: 'Let the waters under the heaven be gathered together unto one place, and let the dry land appear:' and it was so."

For countless ages, "chaos and old night," had enwrapped the globe. Its molten billows had surged and tossed in mad turmoil, while enveloping clouds of murky vapors hid the fiery mass from sight.

But as ages pass away, and radiation into space cools the glowing sphere, the vapors become less dense, the light divides from the darkness, and a crust forms over the liquid globe, soon to be rent by internal convulsion, upheaved or submerged by the gigantic forces at work, partially melted and again solidified, till at length a continental basis is assured.

Now, with still diminishing heat, the aqueous vapor begins to condense, forming oceans, and this first great and final differentiation into land and sea is accomplished.

The V-shaped Laurentian Highlands appear, constituting the back bone of the continent, and determining the direction of its future extension, while parallel with the eastern arm, emerge the peaks now seen in the Adirondaeks of New York, the Highlands of New Jersey, portions of the Blue Ridge of Pennsylvania, Virginia, and the regions farther southwest, including the Black Hills of North Carolina.

Around the bases of these peaks was doubtless, even then, a great mass of gneissoid and quartzose rocks, making great shoals and forming a long line of barrier reefs, protecting the quiet interior basin from the fury of the pelagic waves.

As succeeding ages rolled away, in the slowly sinking trough on the west, were deposited during Silurian, Devonian and Carboniferous ages, strata of sandstones, limestones, conglomerates, shales, beds of iron and coal, aggregating in some places 40,000 feet, till at the close of

Paleozoic time came a mighty convulsion, the overburdened crust giving way under the enormous pressure from above, and the lateral pressure of a cooling globe, and flexing, fracturing, tilting, uplifting these strata, sometimes to the height of more than 10,000 feet.

Then and thus was the great mass of the Appalachian System permanently raised above the ocean, and unimportant have been the changes since, except by erosion, as on the east the waves thundering against its rocky base have pulverized and spread out the sand which lines our coast from Cape Cod to Florida; and on the west the rains and the rivers have prepared and distributed the fertile soil of the Mississippi Valley, and then woven over it a net-work of water courses.

This mountain mass, this great continental fold, extends from the promontory of Gaspé on the Gulf of St. Lawrence, to northern Georgia and Alabama, for about 1,300 miles, in an undulating line, with a general trend from northeast to southwest, and presents very different aspects in different parts of its course.

On the east, a gently sloping plain extends from the mountains to the ocean, about 50 miles wide in New England, almost disappearing near the Hudson, and then in the Pine Barrens of New Jersey, and the Eastern Shore, gradually widening, till in North Carolina, South Carolina, and Georgia, it attains a width of 200 miles, while seaward, it extends from 20 to 100 miles farther, forming those extensive shoals which line the coast from Newfoundland to Florida.

Its elevation above the sea, at the foot of the mountains, is, in New England, from 300 to 500 feet. In the valley of the Hudson, it rises but little above the sea level, but as we go farther south, into Virginia, the Carolinas and Georgia, it attains an altitude of over 1,000 feet, forming a plateau of considerable extent, known as the Piedmont Region, and presenting like the similar plateaus between the parallel mountain chains, a most attractive combination of beautiful scenery, fertile soil, and a climate, for comfort and healthfulness, unsurpassed on the globe.

A remarkable feature of this system is a large central valley running its entire length from north to south, called by Mr. Rogers, the Great Appalachian Valley.

It begins with the basin of Lake Champlain and the valley, of the Hudson; in Pennsylvania is known as the Kittatinny or Cumberland Valley; in Virginia, the Great Valley widening out at last into the Valley of East Tennessee.

But while there is this continuity, there is also much of contrast.

The Appalachian system naturally divides into three sections, each differing in many respects from the others.

The first division extends from Gaspé to the Hudson, mainly a single range, known in its different portions, as the Canadian Highlands, Green Mountains, and Highlands of New York, with the outlying groups of Katahdin in Maine, and the White Mountains of New Hampshire on the east, and the Adirondacks of New York on the west.

This chain is broken through by the Hudson and Mohawk, and attains its minimum of altitude and width, in the vicinity of these rivers.

Four hundred feet rise in the waters of the ocean would separate all this northern division from the American continent; one hundred and forty feet would make an island of all New England and the British possessions as far as Gaspé, for the bottom of the valley occupied by Lake Champlain and the Hudson does not, anywhere, exceed this level.

This was the first route across the country traversed by canal and railroad. It seems probable that this depression is the result of a subsidence of that portion of the system, at a period subsequent to that of its original elevation, and it is proved that all New Jersey, from Cape May to New York, is undergoing a gradual subsidence. Along portions of the coast the remains of submerged forests are now visible under water, and the soundings of the Coast Survey have determined the existence of an ancient channel, a continuation of that of the Hudson, leading far out to sea, which could have been excavated only when the present bottom of the sea occupied a higher level.

The central portion extends for about 450 miles, from the Hudson to the New River in Virginia, known farther along in its course as the Great Kanawha, is commonly spoken of as the Alleghanies, and consists of many long, parallel chains, separated by fertile valleys, and interrupted here and there by notches and gaps, through which the rivers find their way to the sea.

It is in threading these mountain defiles, and now and then crossing a ridge by zigzag approaches, that the Baltimore and Ohio, and Pennsylvania railroads afford the passenger, views of such surpassing beauty and grandeur.

The system attains its greatest width in Pennsylvania, gradually narrowing farther south, but attaining greater elevation, rising from 800 to 1,500, 2,000, 2,500 feet, and in the Peaks of Otter, in Virginia, reaching an altitude of 4,000 feet.

In Virginia the eastern chain is called the Blue Ridge, the extreme western range the Cumberland, while the higher range or ranges between is known as the Alleghanies. Thus far the system, though no longer single, is composed of similar parallel wave-like ridges, separated by longitudinal valleys.

From the New River south, this is changed, and the system becomes greatly complicated.

The main chain, hitherto known as the Blue Ridge, is deflected to the southwest, and in a circuitous line for 250 or 300 miles, under the names of Iron, Stone, Bald, Great Smoky, and Unaka mountains, forms the boundary line between North Carolina and Tennessee, rising frequently to heights exceeding 6,000 feet.

While the more easterly range, thence bearing the name of Blue Ridge, and finding its southern terminus at Caesar's Head, in South Carolina, where the ridge turns abruptly to the northwest, reaches even loftier attitudes, Mitchell's High Peak rising to 6,717 feet.

In North Carolina, these two ranges are more than 50 miles apart, and for more than 100 miles they constitute a great central plateau like that of Colorado, on a small scale.

Instead, however, of a continuous longitudinal valley between these chains, like the Great Valley of Virginia, we find them connected by transverse chains which likewise "divide this valley into great basins, at the bottom of each one of which runs one of those mountain tributaries of the Tennessee, which by the abundance of their waters, merit the name of the true sources of that noble river."

Thus the Roan and Big Yellow chains separate the basin of the Watauga, from that of the Nolichucky, while the northwest ridge of the Black Mountains makes a "divide" between this last, and the French Broad.

Between the New Found and the Great Balsam Mountains, rises the Big Pigeon River, while from the basin between the Great Balsam, and the Cowee ranges, flows out the Tuckasegee.

Next comes the Little Tennessee, and then beyond the Nantahela range, the Hiwassee river, separated by the Stansbury Mountains from the Toccoa, the last of these mountain tributaries of the Tennessee.

And, as all these, with many other rivers, rise in the northwestern slope of the Blue Ridge, draining that large area, and are then forced to cut their way through the gaps and gorges and defiles of the central chain, with its average altitude of nearly 6,000 feet, it is not strange that here is found some of the grandest and most picturesque scenery to be found in the Union.

On the Atlantic slope, the Roanoke, Catawba, Savannah, and other rivers reach the lower levels with much less difficulty.

Says Prof. Guyot* who has devoted much time to mountain exploration, and done more, perhaps, than any other man to make us acquainted with our own mountains, and to whom I would here acknowledge my indebtedness for many of the facts and not a few of the generalizations and descriptions of this lecture—"Here, then, through an ex-

*Article on the Appalachian Mountain system, *American Journal of Science*, March, 1861.

tent of more than 150 miles, the mean height of the valley from which the mountains rise is more than 2,000 feet; the mountains which reach 6,000 feet are counted by scores, and the loftiest peaks rise above 6,700 feet, while at the north, in the group of the White Mountains, the base is scarcely 1,000 feet, the gaps 2,000 feet, and Mount Washington, the only one which rises above 6,000 feet, is still 400 feet below the height of the Black Dome of the Black Mountains.

“Here then is, in all respects, the culminating region of the vast Appalachian system.”

We will now consider somewhat more in detail, the contrasts already in part suggested, between the northern and the southern divisions, and will take as a representative of the one, Mount Washington, in New Hampshire, with an altitude of 6,288 feet, and for the other, Roan Mountain, North Carolina, reaching 6,391 feet.

First, we will contrast the modes of approach. From Portland, Maine, a railroad trip of about 100 miles carries us through a rolling country, becoming hilly as we approach the mountains, and exhibits a flora characteristic of the latitude, and changing but little till one is half way up the mountain; a railway takes us to the very summit.

From Norfolk, Va., for 100 miles of railroad through the tide-water region to Petersburg, we pass over a sandy plain nowhere 100 feet above the sea level, and at Petersburg only 11 feet. Thence another 100 miles brings us to Lynchburg, through a rolling country, rising as high as 800 feet—and from there on we plunge among and climb up mountains and plateaus, the railroad reaching an elevation of 1,500 feet within the first 60 miles, and for the next 150 miles nowhere descending lower than that, but attaining in places an altitude of over 2,500 feet, till at Johnson City, Tenn., steam power deserts us. A rough stage ride of 25 miles, crossing the state line into North Carolina, exhibits a striking contrast in the flora.

Following Buffalo Creek for 10 miles in a southwesterly direction, parallel with Buffalo mountain, we travel through

a limestone region, the water so hard that strangers are often made sick by its use, and the vegetation not unlike that of Virginia—forests, wild flowers, crops and weeds, sassafras patches, blackberry briars, and all.

Then we turn abruptly to the southeast, over limestone ridges, across a slight water-shed, half a mile in width and 50 feet in height, and we are in a quartzite, or as they call it there, "freestone" region, the water cool, clear, and pure, and in a few moments we plunge into a grove of hemlocks, pines, spruces, and sugar-maples, with huckleberries and wintergreen beneath, that reminds us of New England, while the thickets of rhododendron, leucothoe, calycanthus, oxydendron, and magnolia prove to us that we are still in Dixie.

Over the Iron Mountain range, climbing wearily up and then rattling furiously down its 1,500 feet of elevation, and we come to the base of Roan Mountain, standing out in the sunshine more than 3,000 feet above us. For seven miles we wind in and out among cliffs and around the heads of ravines, over a road skillfully engineered, but far from reassuring to weak nerves, and at length we stand on the summit, upon the boundary line between North Carolina and Tennessee, looking off upon these two States, and, in addition, catching glimpses of Virginia, West Virginia, South Carolina, Georgia, and Kentucky.

In strong contrast, likewise, to the spacious Tip-Top house of Mount Washington, securely anchored by huge chains to its granite foundations, is the rough log-house of Cloudland Hotel nestled among the firs, where, two years ago, a party of twenty-five Washingtonians found comfortable quarters for two months, spending the coolest summer of our lives, and to some of us, at least, the most enjoyable.

Contrasting the mountains themselves, we begin the ascent of Mount Washington, in a forest identical with that of the surrounding country. When we reach 3,000 feet, all the trees have grown perceptibly smaller, and all the deciduous trees, except, perhaps, the dwarf birches and mountain ashes, have disappeared. In another 1,000 feet the ever-

greens have become dwarfed to shrubs, three or four feet high, so dense that you may often walk for rods upon their tops. At 5,000 feet, only a few creeping shrubs remain, and for the remaining 1,200 feet we have only a ridge of barren rocks, with here and there a few grasses and sedges, and a few heaths and mosses with the arctic sandwort, *Arenaria Grœnlandica*, keeping up the struggle for existence.

Ascending Roan mountain, at between 3,000 and 4,000 feet of altitude, we pass through a belt of giant trees. One chestnut measured 24 feet in circumference at five feet from the ground; one black cherry (*Prunus serotina*) measured 19 feet, and as straight as a pine, rose 70 feet without a limb, while hundreds of chestnuts, sugar maples, lindens, and tulip trees were seen from four to seven feet in diameter, and 70 or 80 feet to the first limb.

During the next 2,000 feet the deciduous trees gradually disappear, till hemlocks, firs, and spruces alone remain.

At length, emerging from the belt of evergreens surrounding, and in places coming to the very summit, we come out upon a grassy slope of 1,000 acres, the soil rich, black, and a foot or two deep, largely composed of vegetable humus, the grass of a most vivid green, and dotted here and there with clumps of mountain alder, (*Alnus viridis*,) and mountain laurel, (*Rhododendron Catawbiense*,) the latter one of the most beautiful shrubs that can be imagined, forming symmetrical domes of dark pink, from 6 to 8 feet high. Add to this large areas of mountain honeysuckle, (*Rhododendron calendulacum*,) with great masses of bloom, varying from golden yellow to deep crimson, so that the hillside seems a flame of fire, and you can cease to wonder that Dr. Gray, who first explored this mountain in 1841, pronounces it the most beautiful of American mountains.

These grassy summits or "balds," are a marked feature of these southern Appalachians, giving a name to one long range, and raise an interesting question as to what climatic or other changes, have sufficed, first, to stimulate a forest growth of deciduous trees sufficient to account for such an

accumulation of vegetable mould, and then so completely to destroy these forests as to leave no trace behind.

At either end, this grassy slope is terminated by a rocky summit, on which, however, shrubs, grasses, and flowers grow in profusion, but rising some 70 or 80 feet above the plain below, these summits being about two miles apart, and the southern one terminating in cliffs, hundreds of feet in perpendicular height.

As regards the flora on Mount Washington, for the first 5,000 feet we find but few species which are not observed around the base, but above that occur some 60 alpine or sub-alpine species not met with at lower levels, till we approach Labrador or even Greenland.

As we ascend from 3,000 to 5,000 feet on Roan mountain we find the flora recalling that of the thick woods of Maine and New Hampshire. Twenty characteristic species of the northern woods are abundant, while closely associated with them are some 30 species distinctively southern.

Perhaps 30 species more are confined to the upper 1,000 feet.

Some of these are sub-alpine, and replace those of Mount Washington with different species of the same or kindred genera, as *Arenaria glabra* in place of *A. Grœnlandica*; *Prenanthes Roanensis*, in place of *P. nanus* and *Boottii*; *Vaccinium erythrocarpon*, a straggling shrub three or four feet high, in place of *V. Vitis-idaea*, a compact creeping mass; *Rhododendron Catawbiense*, with its magnificent domes of bloom, in place of the little *R. Lapponicum*, only three or four inches in height; *Carex acutivalis* and *juncea*, in place of *C. atrata*, *scirpoides*, and others.

The beautiful *Solidago thyrsoides* of the lower slopes of Mount Washington is replaced on the summit of Roan, by a kindred species, in similar luxuriance and abundance, *S. glomerata*. *Paronychia argyrocoma*, found only in the Willey Notch of the White Mountains, occurs on Roan only on the summit of Eagle Cliff.

Three species, *Alnus viridis*, *Veratrum viride*, and *Lycopo-*

diurn Selago, are found in similar situations on the two mountains, only about 1,000 feet lower on Mount Washington.

As would be expected from the flora, the contrast between the temperatures of these different mountains is very striking.

On one of my last visits to Mount Washington, July 12, the mercury stood at 36° , and the wind was blowing at the rate of 40 miles an hour.

While on Roan, during nine weeks from June to September, the mercury once indicated 75° , seven times only was it above 70° , once it was 45° , and only three times was it below 50° . Three days out of five the daily extremes would be comprised between 55° and 65° .

The equability of barometrical pressure was noteworthy, the mean height of the mercurial column being a little less than 24 inches, while the highest was 24.19, the lowest 23.87, or a variation of only .32. The corrected mean of all the observations compared with those of the nearest station of the Weather Service, at Knoxville, Tenn., gave 6,391 feet as the height of the summit.

As a result of this equability of barometric pressure, was noticed an absence of high winds quite remarkable at that altitude, and quite in contrast with my experience at Mount Washington. At no time, so far as I could judge, did it reach a velocity of 20 miles an hour, and seldom more than from 5 to 10.

Nor, except in one place, was there any indication of the occurrence of a tornado in the past.

It is not surprising that this absolute exemption from heat, with the slight variation in barometric pressure should be found to give absolute exemption from "hay fever." And it is not, perhaps, beyond the limit of scientific induction to hazard the prediction, that among these southern Appalachian mountains and plateaus will be established many a sanitarium, located as regards altitude and exposure, to meet the needs of those afflicted with various forms of pulmonary, bronchial and nervous diseases.

The only remaining contrast that I shall notice will be that of the scenery.

The White Mountains are at one side of the main chain.

In the distance we see on the west the Green Mountains stretching along the horizon.

Immediately around are the sister peaks of the White Mountain and Franconia ranges, but neither on the north, east, or the south, are any lofty mountains in sight; while in all these directions lakes, ponds, rivers, and streams diversify and beautify the landscape.

From Roan, the view is widely different. "Mountains to right of us, mountains to left of us," stretching away on every side to the horizon, mountain monarchs every one, scores over 6,000 feet in height, hardly a level acre in sight, even the valleys 2,000 or 3,000 feet above sea level, and in all this wide expanse, only one little glimpse of water, where a dozen miles away, the Nolichucky is hurrying on to the Tennessee.

On the south we look up to the Black Mountain range, with Mitchell's High Peak, on which rest the bones of its intrepid explorer, rising more than 3,000 feet above us.

On the east and southeast the Blue Ridge is in sight with Grandfather and Grandmother mountains and countless unnamed peaks.

On the north and west, the great plateau of Tennessee, with the Clinch and other ranges, or rather plateaus, twenty or more in number, stretching away in long parallel lines, as level as so many railroad embankments, sometimes for 40 or 50 miles with no apparent gap or peak, till in the dim distance the blue line of the Cumberland range outlines the horizon.

The cloud views are grand beyond description. Often in the early morning the whole country will be covered with a mass of pure white vapor, like the waters of a shoreless sea, with only here and there a mountain top, like an island, emerging from the billows.

And then as the rays of the rising sun fall upon them,

they assume tints of pink and crimson and gold, and soon with the morning breezes they melt away and the landscape stands revealed in all its freshness and beauty.

Rarely on the clearest day can you stand for half an hour upon one of the high peaks without seeing showers and local storms sweeping over the country in various directions. Often several may be seen at once; not unfrequently one takes a turn and comes over us with most unwelcome suddenness, though very often they are below us.

On two sides of the mountains, deep gulfs or ravines come nearly to the mountain top, so that you may stand on an almost perpendicular precipice and look down into a gulf from 1,000 to 2,000 feet deep, at your very feet, and see the clouds form far below, as a moist air from the valley sweeps up the gorge and meets the cooler temperature of the upper height.

It were well if many of us, citizens of this great Republic, could look upon both the northern and southern divisions of this mighty chain, which has been for so many ages the rampart of our eastern coast, and learn that neither section has a monopoly of nature's gifts.

It were well, if we would learn to contrast and enjoy these varieties of mountain sublimity; that there are mountains and mountains; that, as the stars, one mountain differeth from another mountain in glory.

It were well, if we would learn to study mountains, to acquaint ourselves with their peculiarities, to make them our friends, to know and to love them.

It is well for us, as scientific observers, noting all the facts alike in anthropology and biology, to note and carefully to remember that fact of all history, that mountains have not only deflected the winds and influenced the temperature and rainfall, but have also had a powerful influence upon the dwellers among them; that patriotism has ever flourished most vigorously when nourished by mountain air; that freedom has ever loved to make her home amid mountain peaks; that "men, highminded men, who know their rights, and knowing, dare maintain," whether in Greece, in

Switzerland, or in our own country, have so often come forth from mountain homes.

And in view of this fact, we shall have no cause to wonder that men have loved the mountains, and in so many hearts a responsive chord is struck when they hear the ringing periods of the mountaineer's hymn:

“ For the strength of the hills we bless Thee,
Our God ; our father's God !
Thou hast made Thy children mighty
By the touch of the mountain sod.
The rocks yield founts of courage,
Struck forth, as by Thy rod—
For the strength of the hills we bless Thee,
Our God, our father's God !”

OUTLINES OF SOCIOLOGY.

Lecture delivered in the National Museum, Washington, D. C., April 1, 1882
by Major J. W. POWELL.

By organized association men live together in bodies politic. That men may live in peace, render each other assistance and act together as units for mutual protection, is the purpose subserved by organized association. In order that men may associate their conduct must be regulated. For the regulation of conduct there must be organization, and the plan upon which a body politic is organized depends upon the nature of the regulation for which it is used—organ is adapted to function.

The organization of the body politic constitutes the state. Again, there must be—

First, some method of determining the particulars of conduct that require regulation and the quality and quantity of the regulation required.

Second, there must be means of enforcing regulation.

Third, there must be means of determining whether conduct conforms to rule. The machinery established by a society for accomplishing these purposes constitutes government.

Yet again, there are the rules which the body politic determines to be necessary for peace, mutual assistance, protection, and the common welfare, and these constitute the law.

The science of sociology from the nature of the functions of social organization¹ may be fundamentally divided into three subjects—the constitution of the state, the form of the government, and the regulation embodied in the law—the *state*, the *government*, the *law*.

THE STATE.

A state is a body politic—an organized group of men with an established government and a body of determined

law. In the organization of societies units of different orders are discovered. A society of the highest or first order is made up of a number of societies or groups of a second order, and these may again be made up of a number of groups of a third or fourth order. The term *state* as here used embraces the entire body of men included in the largest unit, and consequently all the men of each subordinate unit, when it refers to the body politic as a group of men, and when it refers to the organization it includes the constituent plan of the largest and its included units. It should be noticed that this use of the term *state* is not consistent with a common practice in this country, but we may illustrate by reference thereto. The term *state* would thus be synonymous with United States, including its several units of States, counties, townships, cities, wards and all other subordinate divisions. The term *state*, then, is used to designate an organized body of people of the highest order embracing all its subsidiary organizations.

SOCIOLOGIC CLASSES.

In the foregoing characterization of the state it has been considered as a body politic organized for civil government, that is, for the regulation of the conduct of the individuals of the state as they are related to each other. But the conduct of the members of the state, or of the entire body politic, may have relations to other bodies politic; so that conduct must be regulated in its internal relations and its external relations.

Now, the relations of state to state may be regulated by common agreement, and they are thus regulated to a large extent. But this regulation is imperfect and weak from the fact that no common government is organized to which all the states are alike obedient. The lack of such a common government for states leads to the settlement of disputes by war. Each state prepares itself to enforce its wishes or defend its rights by resort to arms. It seems probable that in the earliest stages of society all able-bodied men take part in its military affairs. But very early a differentiation is

discovered by which a part only of the men belong to the army; and thus we have the *military* class as distinguished from the *civil* class.

In all governments which have hitherto existed, human conduct has been regulated in its relations to supernatural beings. It has always been believed that the welfare of mankind depends largely or even primarily upon the will of the gods, or of one god—the Supreme Ruler of the Universe.

The relation of man to his god gives rise to religion. The conduct involved is religious conduct; and hence religion comes to be an important factor in determining the constitution of the state, the nature of the government, and the character of the law.

Thus in the constitution of the state we find three classes of people more or less distinctly differentiated: The civil, the military, and the priestly class. As these classes appear in the constitution of the state they also affect in varying degrees the form of the government, and the relations arising therefrom are regulated by law.

SOCIAL RANKS.

In many stages of society grades or ranks of people are discovered based upon heredity, possession of land, wealth and other circumstances giving rise to aristocracies—common people and slaves—patricians and plebeians.

CORPORATIONS.

In many states two grand classes of organizations are found—the first class is directly related to government and embraces the organizations mentioned above as grouped in different orders. The second class is indirectly related to government. These organizations serve a variety of purposes. Men are organized into societies for religious, charitable, educational, industrial, and other ends, and such societies will here be called corporations. These organizations of the minor class, unlike those of the major class, do not constitute a part of the government, but they form a part of the state and must necessarily be

considered in the plan of the state. While not a part of the government in an important way they are connected therewith. The regulation of conduct involved in the successful working of such corporations may be immediately determined by the bodies of men severally involved and expressed in charters, constitutions, by-laws, and rules of order. But over all these is the law of the government with which the rules or laws of the several minor organizations must conform, and for the ultimate enforcement of which government is to a large extent responsible. Thus we have the major and minor organizations of the state, the major and minor laws of the state, and the government of the state directly enforcing the major laws and indirectly enforcing the minor laws.

The science called sociology in its three great divisions—the state, the government, and the law—deals with all organizations of the people for whatsoever purpose they may be formed.

A part of the regulation of a state belongs to the major, another part to the minor organizations of the state, but the functions of the two classes of regulation are not clearly and permanently differentiated. A particular system of regulation may be relegated now to the government, and now to a society of the minor class, or the system of regulation may be divided between them. For example, the government may entirely control a system of education, or the system of education may be entirely controlled by minor societies; or, again, a part of the educational system may belong to the government, and a part to minor societies. The boundary lines between major and minor regulation are ever shifting.

A STATE IS A PLEXUS OF ORGANIZATIONS.

In the foregoing statement it is seen that the grand unit of social organization, the state, is itself composed of many minor organizations forming units in a descending series, so that the state has a compound structure. It also has a complex structure. Before defining this complexity an illustration from biology may be in place.

An animal is composed of many organs performing different functions. Thus is found the brain—the organ of thought, the organ of breathing, the organs of digestion, the organs of circulation, the organs of locomotion, and so forth. Running through all these organs and forming a plexus with them, are the systems of tissues. Thus we find the nervous, vascular, and muscular systems, the whole forming a complex tissue of organs, and systems of organs, rendering the organism excessively complex in physical constitution.

In the examination of the constitution of any particular state, it will usually be found that one system of organization permeates and pervades other systems in such a manner that the individual state is found excessively complex. Through the series of units into which the state is organized for the purposes of government, both classes and ranks are interwoven, and through the government units—the classes and the ranks—corporations are interwoven.

In the Muskoki Confederacy there are forty-nine tribes, each one having a government of its own. But these forty-nine tribes are organized in such a manner that a common government is provided for the whole. Now, the confederacy is the grand unit, the tribes are units of a second order. But the clans of one tribe are also the clans of another, so that each clan is distributed through many tribes, and each clan has a government of its own, subsidiary to the government of the tribe, and again subsidiary to the government of the confederacy. The organization for a clan is woven through the organization for a tribe in such a manner as to make the constitution of the state complex.

In those states where the organizations which we have here called corporations are highly developed, the corporations themselves render the constitution of the state complex. Church organizations do not run parallel with state lines, but extend their operations and their control over their own members regardless of political divisions.

All states that have been studied have been thus found, both compound and complex. Such are the essential characteristics of the social organization of mankind into states.

THE GOVERNMENT

The differentiation from the state of an organized system of regulation gives rise to government. If a condition of society could exist in which each member in the state should take an equal and like part with all the others in the regulation of conduct, the state would be without a government in the sense in which that term is here used; but in the bodies politic which are known certain individuals are selected by one or other process to perform special functions in the regulation of the conduct of the people composing the state. The government is the sociologic organ differentiated from the state for the regulation of conduct.

The functions to be performed by a government are of three classes—legislative, executive, and judicial—for if conduct is to be regulated it is necessary—

First, to determine in what particulars, and to establish the rules. This gives the law-making power, which will here be denominated the *legislative* department.

Second, it is necessary to provide machinery for the enforcement of the law. This is here denominated the *executive* department.

Third, in society the particulars of conduct and the relations of conduct are vastly multifarious, approaching infinity. The formulated rules of conduct—the law—can never keep pace with conduct itself, so that every specific act of social life shall have its corresponding formulated rule. It is therefore necessary that the general rules embraced in the law be interpreted and applied to the specific act. This is usually done by the individual, who is supposed and whose duty it is, to know the laws of the state; but the individual may yet have imperfect knowledge. Yet his conduct as a member of the body politic has its effect upon others who themselves may have imperfect knowledge of the law and its application to specific acts. This imperfection of knowledge necessitates an interpretation of the law.

Again, bias of interest, bias of prejudice, and bias of passion—all have their effect in modifying individual opinion

relating to the law. Under these circumstances, it is found necessary for the state to devise, as a part of its government, some organ for the interpretation of the law in its application to specific acts. This gives rise to the *judicial* department of government.

These three great functions have never been clearly differentiated in the organization of a government; but the distinctions have usually been perceived and a partial differentiation of organs is ever found.

In the constitution of the state, it has been seen, three grand classes arise—the *civil*, the *military*, and the *religious*. Wherever in the state such classes appear, the form of government is adapted to the regulation which the constitution of the state demands, and in this manner the functions of government may be classified as civil, military, and religious—the military government inhering in the army, the religious government in the priesthood—and armies and priesthoods are constituent parts of such governments.

Usually in all stages of society, military government is entirely subordinate to civil government, but there are times in the middle stages of society when the military government assumes inordinate proportions, so that the civil government becomes subsidiary thereto; but such military governments performing civil functions are ephemeral.

Again, in the constitution of the state, religious organizations invariably constitute an important factor. In the lowest tribes a priesthood is a part of the government. In certain stages of society a priesthood sometimes acquires inordinate powers, and ecclesiastical or religious governments are organized; but such governments arise only occasionally and are ephemeral.

In the constitution of the state two classes of organizations are found—those relating directly to the government, called the major organizations, and those relating indirectly to the government, called the minor organizations, or corporations, and each corporation develops from its own body of members a government of its own, through which, in part, it is related to the government of the state, and to

other organizations of the minor class. These minor organizations are also related to the government of the state, and to each other directly through the individuals of which they are composed.

Government is the specialized organ for the regulation of the conduct of the individuals of the state, and is functionally divided into the legislative, executive, and judicial departments, with a still further functional division running through these giving civil, military, and religious government. To the government of the state, in its several units and classes, the government of corporations is subsidiary and obedient.

THE LAW.

The law is composed of the rules of conduct which the government endeavors to enforce. These rules of conduct control the individuals of the state in their relations to each other. Conduct, in its relation to the individuals involved, is either directly or indirectly personal. Conduct may be directly personal in its relations to two or more individuals, or it may be indirectly personal in that it affects the relations of the individuals through the medium of property. The first gives rise to what I shall denominate *personal* law, the second to *property* law.

Again, in the organization of the body politic, minor bodies have been described, and designated as *corporations*, including in the term all bodies politic of the minor class, *i. e.*, all private corporations as distinct from municipal or government corporations. The relations of individuals to each other, as members of a corporation, are controlled by the corporations themselves in their organized capacities, but these regulations must conform to the law of the state, and are ultimately relegated for their enforcement to the government. But the control of corporations in their relations to each other, in their relations to the government, and in their relations to the individuals of the state, gives rise to a body of *corporation* law.

Again, since government is differentiated as the organ of

regulation, the organ itself must be controlled—the conduct of the government must be regulated. This gives rise to what I shall denominate *government* law.

It has been seen that the conduct of a state, and of the individuals of a state, has relation to other states. The rules for the regulation of this conduct gives rise to *international* law.

As no common government exists between states to enforce international law, armies are organized, and for the regulation of their conduct *military* law is developed.

The conduct relating to the relation which exists between men and deity gives rise to the organization of ecclesiastical bodies. For the government of these bodies, and for the enforcement of the rules of conduct which religion imposes, *religious* law appears.

The law, then, which is the body of rules which the state endeavors directly or indirectly to enforce, may be properly classed, as follows :

1. Personal law.
2. Property law.
3. Corporation law.
4. Government law.
5. International law.
6. Military law.
7. Religious law.

In addition to this classification of law on the basis of the particulars of conduct to be controlled, another fundamental classification is found running through and interwoven with each of the others. This classification depends upon the method by which regulation is accomplished. General rules of conduct are established, and these general rules are applied to specific acts. Thus duties and rights, or rights active and passive, are determined. Usually, to these rules determining rights, the individuals of the state conform their conduct; but to an important extent they do not. To the extent that conduct is conformatory to the law, right is done; to the extent that conduct is

not in conformity with the law, wrong is done. Now, government does not attempt to control conduct by directly enforcing right-doing, but indirectly, by punishing wrong-doing, and this gives rise to a body of laws relating to wrongs which may be designated as *criminal* law.

Crimes may be committed against personal law, property law, corporation law, government law, international law, military law, and religious law; so that the classification of law relating to rights and duties furnishes the proper basis for the classification of law relating to wrongs, *i. e.* crimes.

COURSE OF EVOLUTION OF THE STATE.

In considering the particulars of conduct that states have attempted to regulate we find they can be classified on still another basis than that presented in considering the subject of law. Conduct may relate to the perpetuation of the species, or conduct may relate to the welfare of the individual. Though this classification serves no important purpose in the study of the subject of law, yet it is necessary in considering the constitution of the state and the form of the government.

In the earlier and lower stages of society conduct relating to the perpetuation of the species is held to be of primary importance, while conduct relating to the welfare of individuals is held to be of secondary importance, in such a manner that the organization of the state is based primarily on the former and secondarily on the latter.

In the perpetuation of the species the functions of reproduction are dependent upon the biologic organization of mankind, dividing the human race into two classes—*male* and *female*—and the very earliest states yet discovered have their plans of organization based on sex, and composed of classified bodies of kindred.

This may be stated in another way. In the earliest forms of society conduct involving the relations of the sexes and the relations of kindred arising therefrom was first brought under regulation. The primary and principal source of disagreement among primitive men at the inception of or-

ganized society grew out of their desires for the possession of women. Men first came into conflict with each other on account of women, and to live together in peace it became necessary to organize government and enact law regulating marriage and kinship relations arising therefrom.

The government and the law relate primarily to kinship, regulating the relation of the sexes, and the relation of the several members of bodies of kindred; that is, the state is organized on kinship. Governmental functions are performed by men whose positions in the government are determined by kinship, and rules relating to kinship and the reproduction of the species constitute the larger body of the law. The law regulates marriage and the rights and duties of the several members of a body of kindred to each other. Individuals are held responsible only to their kindred, and certain groups of kindred are held responsible to other groups of kindred. When other conduct, such as the distribution of game taken from the forest or fish from the sea is regulated, the rules or laws pertaining thereto involve considerations of kinship, and this is extended so far that a large body of rights to property are kinship rights. In this manner all the earlier forms of the state of which we have knowledge are based on kinship. This gives us kinship society and tribal government.

In the highest forms of social organization discovered in the nations of civilization the regulation of conduct discovered in the government and the law, relates chiefly and primarily to the welfare of the individual, and secondarily to the perpetuation of the species: and of the conduct relating to the welfare of the individual that which relates to property has an overwhelming predominance.

In the earliest stages of society small wealth is accumulated, and industries for the production of property and wealth are comparatively undeveloped. In the higher stages of society greatly accumulated wealth is found, and industries are differentiated and industrial organizations multiplied beyond all others. As therefore the organs of government must be adapted to its functions, the plan of

government in such a state must be based upon property. Thus property, society, and national government are constituted.

In kinship states the fundamental classification of the people for the purposes of government is by kindred; in the property state the fundamental classification of people for purposes of government is by territory. Between these stages—the lowest and the highest—many intermediate forms are found. No hard and fast lines can be drawn. A clear distinction can be made only between the lowest and the highest. Survivals of kinship society exist in all governments where position, *i. e.* office, in the government is hereditary, and property society with the government of the highest civilization is reached only by republics. The history of the constitution of the state is the history of the evolution of kinship society into property society.

There is yet another way by which this evolution may be characterized, namely, by the progressing differentiation of the organs of the state, and by the progressing integrations of states.

The differentiation of organs in the state is represented in three ways—

First, by the multiplication of organs of government—a subject which will be considered under the head of government:

Second, by the multiplication of the orders of units and the specialization of the subordinate units so that subordinate organizations perform special functions. Thus cities may be divided into wards, counties into towns; and

Third, by the multiplication of corporations for specific purposes. Such organizations appear in the lowest stages of society only in a crude form, but as society advances they are perfected, and greatly multiplied, until in modern civilized society a state becomes a vast plexus of corporations.

In the earlier stages of society each state is small, being composed only of a body of kindred by consanguinity and affinity, actual or artificial. As each state is small many states are found. In order that unification of states may pro-

gress organization by kinship must give way, and gradually it does give way, to be replaced by organization on a property basis. Organization on a property basis appears in many ways, but chiefly in two—first, captives in war and other persons are made slaves, and become property themselves; and, second, a particular form of property—land—gradually comes to be of prime importance, and is at last taken as the basis of the primary classification of the state, which is territorial.

By various processes of alliance, by conquest, by development of feudalities, and by slavery, states are integrated, and by the development of the organs of government and private corporations, the classes of the state are differentiated, and with this the plan of the state is changed from a kinship to a property basis.

COURSE OF EVOLUTION OF GOVERNMENT.

The earliest form of government of which we have knowledge consists of an assembly composed of men, from which are excluded all deemed too young or too old to exhibit due wisdom. This assembly is the law-making power, *i. e.*, the legislature, and the law applying power, *i. e.*, the court. It is, in fact, the body of able men meeting to confer and decide upon conduct, and is essentially legislature and judiciary undifferentiated. This assembly has a presiding officer who obtains the position by common consent or formal choice, and who sometimes acts as an executive officer in carrying out the decisions of the assembly. But this executive power, though it may sometimes, does not invariably inhere in the presiding officer.

Sometimes, and perhaps usually, the executive power is delegated to a committee of the assembly. The committee may be appointed temporarily to carry out a specific determination of the assembly, or it may be a standing committee to carry out a class of determinations. The form of government thus described probably exists at present in some of the tribes of Australia and elsewhere, as such accounts are given by travelers and students of ethnol-

ogy; but these accounts are incomplete, and have been made by persons not thoroughly trained in this branch of anthropologic research, so that altogether the existence of such a government is at present uncertain. It is also probable that this form of government has existed in past times among tribes who have now advanced beyond it. The line of argument on which this is based cannot here be presented, and it is but fair to say that positive conclusions have not been reached.

A somewhat higher form of Government has been discovered in America and elsewhere, which may be more thoroughly described. In this the assembly of the people is more definitely organized. The presiding officer is formally selected, and his tenure of office is for life, unless otherwise formally determined by the assembly for cause. In addition to this, a chief or system of chiefs is found whose duties are executive. The chief is also a member of the assembly, but is not a chief by virtue of such membership but by choice of the people. The chieftaincy is never hereditary.

In the most highly developed governments the three great classifications of governmental functions are highly, though not completely, differentiated, giving rise to legislative, executive, and judicial departments, represented by the *assembly*, the *ruler*, and the *court*.

The assembly itself is elaborately organized and differentiated into two or more correlated divisions. Executive functions are highly differentiated and distributed among various classes of officers over whom the ruler presides. The judicial functions also are differentiated, and superior and subordinate courts are organized. Between the two forms thus described, many intermediate forms are discovered, and the course of progress is wayward and various. In the earlier part of this course, judicial functions are to a greater or less extent assumed by the executive, and for a long time this division of the functions of the court between the two departments of government continues—being claimed, now by one, now by the other. At times, too, in the course of

progress, legislative functions are assumed by the executive department, and a conflict is waged for supremacy. At last, by various processes, the court is organized.

Three of these processes must here be mentioned. As states increase in size the business of adjudication becomes so great that proper attention cannot be given to the multiplicity of cases arising. Under these circumstances committees of the assembly are appointed with judicial powers, at first extremely limited but gradually enlarged, until courts are developed. On the other hand, where judicial power has to a greater or less extent been assumed by the executive department, the rulers find themselves overwhelmed with business and appoint subordinates in the first instance to adjudicate specific cases, but gradually the powers of these subordinates are enlarged, until courts are thus established.

Again, ecclesiastical bodies claiming superior virtue and wisdom sometimes assume to adjudicate, but such adjudication is gradually relegated to specified officers of the body, and thus ecclesiastical courts are developed.

The courts originating from the assembly from the ruler and from the ecclesiastical body alike, may be more or less multifarious. When they spring up in the same state their jurisdiction is at first imperfectly defined. Each strives for supremacy, and thus jurisdiction overlaps jurisdiction. This conflict ultimately results in the organization of a system of courts integrated in a superior court, and differentiated by the establishment of a variety of inferior courts with jurisdiction more carefully defined—the function of the inferior courts being controlled and restricted within proper bounds by appeal to the superior.

Thus, at last, the functions of the primitive assembly, originally legislative, executive, and judicial, are differentiated, and the legislature, the ruler, and the court are established.

THE COURSE OF EVOLUTION OF LAW.

In the development of the tribe into the nation, conduct develops from extreme simplicity to extreme complexity,

and for the regulation of conduct the law must likewise develop.

PERSONAL LAW

A large part of personal law belongs to family law. Perhaps the earliest and lowest form of the family is that in which brothers in a group marry their own sisters in a group: all the brothers are the husbands of all the sisters. The family is thus composed of husbands and wives, parents and children, grand parents and grand children and brothers and sisters. Collateral lines of kinship are not established. There are no uncles and aunts, no male cousins and no female cousins, and no nephews and nieces. This is known as the Punaluan family or system of kinship.

Another form, known as the Malayan family or system of kinship, is found involving a larger tribe and a higher organization. In this, a group of men being brothers, marry a group of women, sisters to each other, but not sisters to the men whom they marry. For the regulation of this form of communal marriage, a tribe is divided into classes. Often there are three classes which are divided into male and female—making in all, six. Let these be represented by letters: A represents a male class, and A¹ a female class. The class A are brothers and the class A¹ are sisters. B represents a class, and B¹ a class, brothers and sisters; and C and C¹ are like classes. Then the class A, being brothers to each other, may not marry their sisters A¹, but marry the class of women B¹ who are sisters to each other. The class B marry the class C¹, and the class C marry the class A¹. Now, in this family, descent is in the female line. The children then of A and B¹ will belong to the class B and B¹, the children of B and C¹ will belong to the class C and C¹, and the children of C and A¹ will belong to the class A and A¹, and through these cycles the generations pass.

The kinship system is further developed in this family, and gives brothers and sisters, fathers and mothers, sons and daughters, grandfathers and grandmothers, and grand-sons

and daughters. It also gives aunts and uncles. The children call their father and father's brothers, all fathers, and their mother and mother's sisters, all mothers; but their father's sisters are aunts, and their mother's brothers are uncles. The children of their father's brothers they call brothers, the children of their mother's sisters they call sisters; but the children of their father's sisters they call cousins, and the children of their mother's brothers they call cousins.

This family is widely spread in Australia and elsewhere and the kinship system is still more widely spread as it exists among all the tribes of North and South America and elsewhere in Europe, Asia, and Africa, and in some of the islands of the sea.

The Punaluan system of kinship at first described is known to exist, but the form of communal marriage is not known. The Malayan system of kinship and marriage is known.

The simplest and most common form only has been given.

The development of this into the polygamic and monogamic systems of marriage is accomplished in diverse ways among many tribes. The group of husbands and group of wives constituting one family comes to be very large and narrower restrictions are adopted, thus boys of one mother will be married in a group to the daughters of another mother, and various other restrictive regulations will appear, but all involving a common principle, namely, that the husbands and wives have no choice. Selection is made by legal appointment. Legal appointment develops into individual selection through three processes:

First, the parties interested consulting their own wishes, elope; and marriage by elopement though illegal at first, is made legal on the day of jubilee. This procedure widely prevails among the North American Indians.

Second, it oftentimes happens that in the vicissitude of life certain groups of families of sisters increase in number, while the group of brothers to whom they belong decrease in number, and *vice versa*. Under these circumstances a few men are entitled to many wives, and the law holds this

to be justice. In such cases it may happen that a man who belongs to a large male group, having rights of marriage in a small female group, will, with his friends, capture a bride from some larger group of women. This is always resisted, and conflict ensues. If the capturing party succeed the law then holds that the warfare was the final arbitrament and the controversy ends; and if the capturing party fail the contest must, in like manner, cease.

Third, Marriage by capture develops into a third form. A man being entitled to more than one woman is challenged by a man who, by the vicissitudes of life and death, is entitled to none, and the right to a woman is thus decided by wager of battle between the two men immediately interested. This duel is gradually regulated by law in such a manner that fatal results do not ensue, and the conflict ends controversy, and thereafter the disputants are, themselves, friends.

These three forms of marriage—by elopement, by capture, and by duel, are gradually regulated, and come to be recognized as legal, and so communal marriage is developed into polygamic and monogamic marriage; and thus by a long process the Malayan system of marriage and the Malayan system of kinship are developed into the monogamic family and kinship. But it usually happens that the system of kinship remains longer than the system of marriage, that is, the evolution of language does not keep pace with the evolution of customary law, so we find many tribes having the Malayan system of kinship, yet not having the Malayan system of marriage, but having polygamic marriage, and marriage by legal appointment, and with these marriage by elopement, by capture, and by duel.

In the family law of very early society we discovered that descent is in the female line, that the control of the children belongs to the mother and her consanguineal kindred, and that the father and his kindred have no control over the family. The husband is but the guest of the wife and her friends.

During the process of development from communal marriage, and the system of kinship involved, to monogamic

marriage and its system of kinship, a change from descent in the female to descent in the male line occurs, and with this change the control of the family is relegated to the husband and father, and rapidly this control becomes absolute, and the patriarchal family is established, in which the father has power of life and death over his wives and children and all their descendants, but gradually this power is regulated by law.

A method by which descent is changed from the female to the male line, that is, by which mother-right is changed to father-right, appears among the North American Indians.

When the gentes of which a tribe is composed do not live in a compact village but are spread over a large area of country, so that each gens lives alone separated by miles of distance from the others, the consanguineal relatives of the wives, who are the guardians and masters of the family, are not present and cannot exercise control. Under such circumstances authority is gradually assumed by the husbands and the line of descent is ultimately changed. There may be other methods by which this change is made.

PROPERTY LAW.

Property law is naturally divided into two classes—property in *chattels* and property in *land*.

To a large extent in primitive society chattel property is communal—owned by classes or clans, but a few articles, such as clothing, ornaments, some implements and utensils are owned by individuals, yet no large accumulation of these things is permitted to the individual. Under these circumstances barter and sale are clogged because individuals cannot freely exchange—the consent of two bodies of persons being necessary therefor. As industries are differentiated, that is, in the first beginning of the differentiation of labor, articles are exchanged by regulation—the price is always the legal price. Inheritance is by clan, not from parent to child.

In the progress of social organization communal chattels become personal property. Inheritance by clan gradually becomes inheritance by nearest of kin, and, finally, wills are

invented, and inheritance by designation of the owner is developed. Then with the development of money, barter is changed into sale, and legally fixed price by certain curious processes is changed into competitive price.

In the most primitive society the land is held by the state and used only as a hunting ground, or as the source of vegetal food naturally grown thereon, while the streams and coasts are held as fisheries; but where rude cultivation begins very small areas are redeemed, and usually cultivated land is held by tribe or clan. Thus, tenure to cultivated land is communal.

Communal ownership is gradually developed into ownership in severalty by a variety of processes interesting in themselves, but multifarious and complex, so that the subject may not here be treated at large.

With the change in the character of tenure to property from communal to individual ownership, there grows up a large body of law relating to contract.

[The consideration of the evolution of corporation law is omitted.]

GOVERNMENT LAW.

In lower tribes, government law consists of a few simple rules, regulating the manner of calling the assembly, the order of deliberation, and the method of announcing the decision, while the chief or committee executes the law in obedience to a few equally simple rules. In higher nations, where the legislature, the ruler and the court appear, government law is greatly elaborated. The legislature is organized by processes provided by law, and controlled by organic or constitutional law, and a body of parliamentary law is developed regulating its method of procedure. The executive department is governed by organic law, by law emanating from the legislature and by a large body of rules originating within itself. The judicial department is also controlled by organic law, by directory laws emanating from the legislature, and by the rules of the court, involving a complex system of procedure. From such simplicity to such complexity do we arrive by the processes of evolution.

CRIMINAL LAW.

Of crimes resulting from the regulation of the relations of the sexes, marriage within the prescribed group is held to be the most heinous in primitive society. It is never condoned, never compounded. Infidelity after marriage may be condoned or compounded.

Crimes relating to personal injuries include murder, maiming, and slander. Murder may be punished by the taking of life—not necessarily the life of the murderer, but one of his clan. But murder may be compounded and primitive law fixes the value of individuals according to sex and rank. Murder may be atoned for by substitution, that is, the murdered man may be expatriated, driven from his family, and thus become dead to his own people, and then he may be adopted by the injured family and made to replace the murdered person. Thus the wife of the murdered man may adopt the murderer for her husband, and, in so doing, he loses his own name and all relations of kinship, and accepts the name and kinship relations of the murdered man.

Maiming is punished by maiming—"an eye for an eye and a tooth for a tooth"—and maiming may be compounded, and the value of the several parts of the body is specified by law.

Slander is punished the same as the crime alleged in the slander, and slander may be pleaded as a justifying cause for murder and maiming; slander may also be compounded.

In primitive society by far the largest body of crimes is included under the practice of witchcraft, and this is terribly punished. Abnormal conditions of body, aberrations of mind, and infelicities of temper are all interpreted as evidences that the possessors thereof are uncanny people, and to a large extent deafness and blindness before old age from causes that cannot be readily understood, and all loathsome or strange diseases are likely to be attributed to sorcery, so that the practice of witchcraft is everywhere believed in, and witches and wizards are multiplied. Witchcraft is punished by death, but after conviction in the court, ap-

peal to supernatural decision is always permitted, and thus we have the origin of trial by ordeal.

Criminal law in the higher stages of society need not be characterized, but certain lines of evolution may be pointed out. The groups in which marriage is prohibited, giving rise to the crime of incest, change from artificial groups to groups constituted by degrees of consanguineal kinship, male and female. Thus classifications by artificial and analogous characteristics give place to classifications by essential and homologous characteristics. Gradually too, in the progress of society, from the earliest to the latest stages, the motive of the murderer is considered, and accidental killing and maiming are differentiated from willful murder and other personal injuries, and such willful injuries being essential crimes are, in the higher stages of society, not compounded or atoned for by substitution.

In the crimes which come from the unlawful acquisition of property the punishment by multiple restitution found in the lower states is superseded by fines which go to the state and by imprisonment. In the lower stages of society property crimes are thefts; in the higher stages, property crimes are thefts and frauds.

In the lower stages of society a large body of the crime is witchcraft, and this gradually disappears with the progress of culture. It should be noticed that in early society there is a very large body of artificial crimes—especially those relating to sorcery.

Again, there is a large body of such artificial crimes relating to personal injuries, from the fact that willful injury is not differentiated from accidental injury. In the course of evolution such artificial crimes are eliminated from the law: on the other hand, by reason of the ever increasing complexity of the relations of men, the classes of real crimes are multiplied.

There is yet another line of progress. In primitive society two principles are found to exist side by side as fundamental theories in the administration of the law.

The first is that justice must be done—that justice which the primitive law recognizes.

The second, that there must be end to controversy—that peace may prevail and society be not disorganized; and this must be accomplished though the former fail.

To secure end to controversy, there is resort to two methods—

First, days or other periods of jubilee are appointed at which all crimes, except murder and incest, are forgiven. In the lowest societies it is a day of jubilee, coming once a year; in the highest societies, it is a year of jubilee, coming at longer periods. With progressing society this method of ending controversy is adopted in the case of crimes which are manifestly artificial in the state of culture to which the people have arrived, and by this means willful murder is at first differentiated from accidental killing.

Still another method of terminating controversy and avoiding punishment for artificial crime, is provided for in the establishment of cities of refuge.

Now cities of refuge come to be such in a curious manner. In the early history of mankind, cities are states and autonomous; one state does not punish the crimes committed in another; and men committing crimes flee from their own states to others, and become incorporated therein by adoption, and thus secure immunity from punishment.

When on the first organization of nations, two or more city-states are consolidated and placed under one general government, certain cities often remain as places of refuge, but with an important restriction, namely, that the crimes belong to the classes which have been here described as artificial.

Thus days of jubilee and cities of refuge are important agencies in the evolution of criminal law.

The growth of law in its entire course is governed in many important respects by the theory of the origin of law and the source of its authority. This subject involves the discussion of the evolution of philosophy and cannot now be undertaken. It is the highest and most important subject with which the mind of man can grapple, as it involves the whole theory of human conduct—the ethics of mankind.

LITTLE KNOWN FACTS ABOUT WELL KNOWN ANIMALS.

Lecture delivered in the National Museum, Washington, D. C., April 8, 1882,
by Prof. C. V. RILEY.

LADIES AND GENTLEMEN:

It has already been explained that these lectures are intended to popularize science. Major Powell, in opening the course, very well remarked that to treat scientific subjects in such manner that an ordinary audience may clearly understand is no easy task. Every trade, every art, every profession, has its peculiar vernacular, without which it cannot well be understood or communicated. Condensed technicality that most directly appeals to the intelligence of the specialist is but a mist to becloud the average understanding. Tyndall, in physical science, Agassiz and Huxley in natural history, Proctor in astronomy, and several of our younger American scientists, in various departments, have, it is true, of late years demonstrated that science may be clearly expounded to popular audiences, and that she rather gains in attractiveness by being disrobed of as much as possible of the technicality with which she is generally enveloped; but their success was proportionate to their substitution of object lessons, experiments, or illustrations, for the ordinary technical tools of the understanding.

Without further preface I shall, in order to be intelligible, choose as subjects for my remarks a few animals with which all of you must be more or less familiar and which have common names, and I will endeavor to convey to you by illustration the meaning of such uncommon terms as cannot well be avoided.

To begin, let us go to the ocean, that vasty deep which seems so desolate and yet which teems with curious life maintained only by fierce incessant warfare that makes its bed an ossuary, recording, however feebly, the life it had contained.

Most of you have probably been on the ocean, or have

wandered along its shores; but I will first speak of an animal that all are familiar with in any event.

THE OYSTER.

The oyster in this country forms one of the most common and most esteemed articles of diet, and if you wish to get an accurate idea of the vast importance of the oyster industry, I would refer you to Mr. Ernest Ingersoll's report recently issued from the Census Office. How many persons, while enjoying their oysters—stewed, fried, broiled, scalloped, or from the shell—ever pause to consider anything but the flavor? How many dream that the lifeless and almost shapeless thing so grateful to their palate was at one time a free and active creature, swimming about in the ocean with considerable rapidity!

The oyster is older than man. Evolutionists recognize that stability of life-conditions induces permanency of type, and as the conditions under which the oyster lives must have prevailed at a very early period of the Earth's history we find that the fossil shells of its ancestors are scattered throughout the world wherever ancient oceans had their shores, while they particularly abound in the cretaceous formation. Prof. White, curator of Mollusca in this museum, has kindly loaned me some fossil forms which he finds abounding in the cretaceous of the West. They do not differ materially from others found in the Miocene, and you will see that in all of the hundreds of thousands of years that have passed since then, while, as Prof. Marsh has so well shown us, the present horse was evolving through the various forms of *Eohippus*, *Orohippus*, *Miohippus*, etc., from a typically five-toed ancestor, quite unlike its present self and common to it and other ungulate mammals; while other terrestrial animals were undergoing like mutations, the oyster retained essentially the same form.

However much they may differ in size, appearance and flavor, the present oysters of North America are all referable to one species, scientifically known as *Ostrea virginiana* Lister,

while that of Europe is specifically different and known as *Ostrea edulis* L.

Fig. 1.—Genealogy of the horse: *b*, Orohippus; *c*, Miohippus; *d*, Pliohippus; *e*, Equus. (After Marsh.)

The oyster has generally been considered hermaphrodite, *i. e.*, combining both sexes in one individual; and the young are said to be at first hatched and then protected inside the mantle cavity of the parent. Though this may be true of the European species, Dr. W. K. Brooks, of Johns Hopkins University, by recent admirable researches, has clearly shown that our American oyster has the sexes separated, and that the young are hatched in the free water, and have to take their chance without parental care or protection. Independence is of quicker development in this free country as well in the oyster as in man. Without going into anatomical details I would state that what we know as the "fat" of the oyster forms the reproductive part. The milky fluid from it, in a gravid female, when spread out in a thin film will show innumerable white ovarian specs, even without the aid of a microscope; while that from a well-developed male is more homogeneous and more adhesive. This fluid is expelled in the water at the breeding season, and the egg, once adrift, must meet a male cell or perish. The average number of ova produced by a single female is perhaps ten millions, and a large sized one may produce as many as sixty millions. So you can imagine at what an immense rate they would multiply did they not, in the egg state, form the principal food of hundreds of other creatures; and had they not, in all stages of growth, numerous enemies.

Probably not more than one in several millions reaches

maturity. In nature it is a fundamental principle that the individual should be sacrificed without limit to secure the good and perpetuity of the race, and the principle might be kept in mind to advantage by those who discuss social problems that concern man.

Fig. 2.—*Young of American Oyster*: *A*, surface view of “spat” at first swimming stage, with external opening (*d*) and cilia; *B*, do., somewhat older, showing beginning of shell (*s*); *C*, dorsal view of same still older, showing shell (*s*) much increased in size—all highly magnified. (After Brooks.)

But to our young oyster. Here you have its figure (2)—a soft, irregularly-shaped object, with numerous feelers or cilia, by rotating which it swims about quite rapidly. These young are called “spats” or “spawn” by fishermen, and they swim about till they come in contact with some submarine body, on which they settle, when they are known as “blisters.” They will adhere to any hard, clean object, but not to mud or dirt. No sooner is the young oyster fixed than it begins to elaborate its shell, which is composed chiefly of carbonate of lime. The food of the oyster consists of various minute creatures, such as diatoms, rhizopods, and infusoria, which abound everywhere in water or in mud at the bottom thereof.

You would hardly suppose that this lymphatic mass was endowed with extreme nervous sensibility. Yet it will close

its shell at the slightest vibration and dies from a sudden jar, so that a loud thunder-clap will kill, instantly, a whole boat load. There is good evidence that oysters attain the age of thirty years, and no one knows how much longer they may live.

ENEMIES.—Prolificacy usually decreases as we descend the scale of organic life, and yet, as Darwin has forcibly remarked, even the slow-breeding elephant, if left unchecked, would soon people the earth to the exclusion of all other animals. Hence all creatures have enemies of one kind or another—checks to their undue multiplication. The oyster has many such. In the free swimming stage the young are devoured by all sorts of animals, and even after it becomes fixed it is preyed upon by many, while others are truly parasitic, boring or drilling holes through its shell.

Certain sea-worms, (Branch *Annelides*,) and even a boring sponge, (*Cliona sulphurea* Verrill,) help to perforate the shell, while small boring univalve mollusks belonging to its own Branch do the same thing. They are known in common language as "drills" or "borers," and they work by means of a tongue ribbon, which is supplied with flinty teeth. The large spiral mollusks known by the names of "winkle" and "conch," of which I exhibit an example, prey upon the oyster and crush its shell by sheer muscular power of the large "foot," by which they grasp it. The commonest of these is *Fulgur carica*. They all have an interesting life-history of their own, but I have time only to show you the curious egg-cases of the last named species, which many of you have doubtless found cast upon the beach, strung together as they are in a series of parchment-like disks, diminishing in size toward either end of the string.

There is one enemy of the oyster, however, which, on account of its great destructiveness and its universal occurrence along the seashore, requires more than a passing notice. I allude to the—

STAR-FISH.

Here you have one of these singular creatures, a mere skeleton of its former plump self, when filled with water,

but still showing the general character of the animal with its five fingers or rays, each having, in a median groove beneath, a number of fleshy, disc-tipped tubes, or *ambulacra*, which perform the function of feet, and with its central mouth, a mere circular opening. The common star-fish of the Atlantic coast (*Asterias vulgaris* Stimpson,* fig. 3) is the

Fig. 3. *Asterias vulgaris*. (After A. Agassiz.)

most destructive to the oyster, and may be taken as a type of the radiate animals. The sexes are separate, and the ova are fertilized in the water just as are those of the oyster. The analogy goes yet further, for the young starfish bears no resemblance to its parent, and swims about by means of rotating cilia. At first it is a mere spherical mass, and then becomes bilateral. This first stage is known as the *Bipinnaria* stage, (Fig. 4, *A*, *B*, *C*), and as it grows older a series of arms develop until we have what is known as the *Brachiolaria* stage, (Fig. 4 *D*), a name given to it when its real character was unknown, a bit of zoological ignorance which, upon comparing these figures with the adult, you will agree with me was quite excusable. Those who are curious to learn more

* *Asteracanthion pallidus* A. Agassiz.

of the wonderful transformations which this *Brachiolaria* undergoes should consult the magnificent works of Alexander Agassiz on the subject. I have only time to state that the star-fish proper develops on the ab-oral end of the larva, which it finally absorbs, and that the adult star-fish, with its long arms, is not developed for two or more years, the form meanwhile remaining conical or disc-shaped.

Fig. 4.—Diagrammatic view of young Star-fish: *A, B, C*, Bipinnaria stage in different ages; *D*, Brachiolaria stage. (The black lines represent ciliated bands; the shading the space between the præ-oral and post-oral bands; *m*, the mouth; *an* the anus. (After Müller.)

The star-fish swallows the younger oysters shell and all, and after the soft parts are absorbed the shell is cast out of the stomach by eversion; but older oysters are not so easily managed. To tackle one the star-fish grasps it in his five arms and then little by little breaks off the margin of the shell by the muscles at the entrance of his stomach, and when a sufficient opening has been effected the distensible mouth is intruded until the soft oyster is seized and consumed.

The star-fish must live to an old age, as, according to Agassiz, some 14 years are required for full growth and development. Its ability to reproduce lost members is well known. Certain species like the *Ophiurans*, or brittle-stars, have, in fact, a faculty for dismemberment which is truly marvelous, for they break their limbs to pieces when irritated. The rays, when broken, are renewed, but the stomach, if severed, or

divided, cannot be renewed. The idea, therefore, that oyster fishermen, in cutting up the star-fish, "make two or three star-fishes out of each captive," is evidently erroneous. This insensibility to mutilation is common to a large number of the lower animals found on the coast. The sea-anemones (*Actinozoa*) accomplish even that mathematical paradox, multiplication by division; for when they move from one part of a rock to another, they often leave fragments of themselves behind, and these fragments soon become smooth and spherical, and are transformed to perfect, though minute, anemones. The flat-worms (*Eurylepta*) offer a still more remarkable instance. When cut to pieces, each piece not only continues moving in the direction in which the whole animal was moving at the time, but gradually becomes complete in all its parts—a veritable "chip of the old block." It is related that two polyps often attempt to swallow the same prey, and when this is not easily severed the largest polyp gapes and swallows his antagonist. This last seems, however, to be the gainer by the operation, as, after lying in the conqueror's body for an hour or so it issues unhurt and often in possession of the original bone of contention.

THE CRAB.

Next to the oyster few animals are more often on the tables of the Washingtonian than the crab, and I will ask you to bear his form in mind—whether as you have seen him scampering along sidewise on the sand or dished up "deviled," or in "soft shell;" while I rapidly trace his development. The crab undergoes such changes that it has been known by different names at different periods of its growth, and has been placed in distinct orders. The species most used here and southward is known as *Callinectes hastatus*, but as its early history has not yet, so far as I am aware, been critically studied, I will take the common shore crab (*Cancer irroratus*) as an example, for it is closely allied to the European table crab. Here we have a picture of the newly-hatched or *Zoëa* form. (Fig. 5.) You will agree with me that in this singular, long-bodied, long-spined affair there

is little to recall the creature so familiar to you, though the structure is far better adapted to swimming freely in the

Fig. 5.—Zoea of Crab. (After Smith.)

Fig. 6.—Megalops of Crab. (After Smith.)

water. In some crabs belonging to the genus *Porcellana* the anterior spine or rostrum is supple, and many times longer than the body. After a few months the form changes materially, the mouth-parts, which before were swimming legs, are now fitted for preparing the food, and we have what is known as the *Megalops* condition, which looks much like a lobster, but in which the mature crab is sufficiently foreshadowed. (Fig. 6.)

Let us now leave the ocean and talk of a few of the commoner animals inland.

THE FROG.

The common frog, (*Rana temporaria*,) which occurs both here and in Europe, passes the winter buried in the mud of stagnant waters, in a torpid condition; aye, and it may even be frozen till it is so brittle as to chink, without the loss of life. The frogs are now issuing forth to join with their peculiar croak in the zoölogical concert of spring. The accompanying figures will aid us in understanding the transformations of the frog. They are poor copies of the admirable originals of Roesel von Rosenhof, generally credited to Mivart, because this last author failed to credit them to the proper source. Hatching from dark globular eggs enclosed in a transparent, gelatinous fluid which agglutinates them and enables them to float in masses on the water, the young tadpole congregates under the leaf of some aquatic plant, where it feeds by suction. It has prominent external branchiæ, and is in every respect admirably adapted to aquatic life. The legs are first seen as mere buds, the front pair hidden under the opercular membrane. As they develop the gills are absorbed; the mouth loses its suctorial character; the eyes, instead of being concealed, become exposed, and the front limbs are uncovered. The tail is next gradually absorbed, and the animal is now truly amphibious, for the lungs, which have replaced the gills, enables it to live out of water. From a vegetarian it has become carnivorous and now comes on land in search of worms and

insects, and in such numbers in damp weather as to give rise to the belief, still popularly adhered to in many sections, that it has rained frogs.

Fig. 7. *Transformations of frog*. *a*, newly hatched tadpoles; *b*, same enlarged, showing external gills; *c*, *d*, *e*, later stages, the gills enclosed by the opercular membrane; *f*, stage with hind limbs developing; *g*, after molt with both pairs of limbs showing; *h*, partial atrophy of tail; *i*, full formed young frog. (After Rösel.)

They plunge into the mud again at the approach of winter, but next year and each successive year, go through a performance of which many of you are not probably aware. They cast off their old frozen skin each spring, and this is the way in which it is done, as related by an eye witness. Let us imagine we are on the edge of some swamp and are watching some large fellow who is about to undress himself. Like the rest of his brethren he has had such a shamefully long sleep, that on awakening he feels dull and

stiff, and does not like to appear in society till he has thrown off his old worn-out garments and put on new ones, never hesitating about the fashion, but following the pattern of his ancestors for generation upon generation. He begins by pressing his elbows hard against his sides, and rubbing downwards; he keeps on until the skin on his back bursts, and he then works it into folds on his sides and hips. Now, grasping one hind leg with both his hands, he hauls off one leg of his pants, and there! almost before you can count three, the other goes in the same way. He now takes the cast-off cuticle before him, between his legs, into his mouth and swallows it, and even while it yet descends the gullet, he has torn off the skin underneath, and brought it to his fore legs or hands, and grasping one of these with the other, by considerable pulling he strips them, just as we should strip off a shirt, and by a single motion of the head he draws the skin from the neck and swallows the whole with a c-r-r-r-oak of satisfaction, for he knows full well, that such a dainty morsel he can get but once a year.

Most frogs and toads go through the tadpole development in the water, but in some terrestrial species where marshes are scarce or lacking, the development takes place either before birth or in a marsupium or sac on the back of the parent. The tadpole state may also be indefinitely prolonged, as Jeffries Wyman kept one, of the bullfrog, for seven years, or many more than the natural period of larval existence. The frog is a true vertebrate, belonging to the same great Branch of the animal kingdom as man. Yet the changes it undergoes after birth are as remarkable as are those we have already noticed in the lower Branches. In some allied animals, indeed, development is permanently arrested in the tadpole state, and I will, before passing to a few well-known insects, briefly refer you to a rather remarkable animal which occurs in our brackish Western lakes of high altitudes. I refer to it in order to show how greatly form is influenced by conditions. Here we have figures of it. (Fig. 8.) It was described by Prof. Baird as *Siredon lichenoides*, and, as you will note, has many of the character-

istics of the tadpole of the frog, its external branchiæ and membranous back and tail, well fitting it for aquatic life. Now this *Siredon* will either retain this larval form perma-

Fig. 8. *Amblystoma mavortium* Baird: *a*, larval form or *Siredon lichenoide* Baird, side view; *b*, do., dorsal view; *c*, mature form partially developed and corresponding to *A. maculatum* Hall. —all one-half natural size. (After Marsh.)

nently and perpetuate itself, or else may become transformed into a perfect salamander, under which form it has been referred to another genus and described as *Amblystoma mavortium*. Not only are the dorsal and caudal membranes and the external branchiæ absorbed in the process, but the color changes, the size decreases, and profound changes take place in the external and bony structure. An allied species from the table-lands of Mexico, normally remains and breeds in the *Siredon* state, but will sometimes change, especially if

brought under changed influences. The Siredon form of this last is known by the rather unpronounceable name of Axolotl, or Awahgolotel as the Mexicans speak it, and the mature form is *Amblystoma mexicanum*.

It greatly resembles the species first mentioned, and since this has been referred by different authors to three or four different genera and varies so as to have had at least half a dozen specific names given to it, we may pretty safely assume that the Mexican form is also but a well-marked variety. Most reptiles, and especially batrachians, vary much in color, and have the power in greater or less degree of simulating that of their surroundings. The common tree-toad is a familiar example; so that the discussion about species may sometimes be likened to the quarrel of the knights who were looking on different sides of the same shield. Before leaving the Siredon I desire to say, in justice to the able and beloved director of this Museum, that already in 1849, or long before their specific connection had been established by experiment, he correctly inferred that Siredon would prove to be the larva of *Amblystoma*.

THE HOUSE-FLY.

The most persistent companion of man is, perhaps, the house-fly. It has followed him everywhere in his own conveyances, and is found, so far as we know, wherever civilized man has established himself. Our American house-fly was described as a distinct species (*Musca harpyia*) by Harris, but Packard found it, after critical comparisons, specifically identical with the Linnaean species. Already, with the growing warmth of this beautiful spring month, the fly begins to show its familiar form in our houses, and to inspire the careful housekeeper with feelings anything but agreeable. Whence comes it? How has it passed the winter? Such questions are often asked. Let us answer them. Not all who have watched the fly poising or darting noiselessly and gracefully in mid-air, or deftly making its toilet, have realized that at one time it was a crawling maggot, as unlike its perfect self as two things well can be. The eggs are about

four-hundredths of an inch long, one-fourth as wide, dull white in color, and pitted with elongate, hexagonal depressions—mere whitish specks to the unaided eye, laid in little agglutinated piles in warm manure or in decomposing vegetation, especially that about our stables and barn-yards. From 80 to 100 are laid at a time, and probably at three or four different intervals by the same fly, though on this point we have no exact data. Within 24 hours, in summer, they hatch into footless maggots, which, after rioting in filth till their tender skins seem ready to burst from repletion become full-fed in less than a week and, descending into the earth or sheltering under some old board, contract to brown, shining objects, rounded at both ends, and technically known as puparia. Within the darkness of this hardened skin profound changes rapidly take place, and the insect passes through the pupa to the perfect state, and finally, in about five days, the anterior end of the puparium is pushed off and the fly quickly crawls out. At first its parts are pale and soft, and its wings are crumpled and useless, but these soon expand, and suddenly, without practice or teaching the new-fledged fly wings its way to your table to mock your displeasure—to share your repast. The length of time required from hatching to maturity varies with the season and temperature, but will not exceed ten days in midsummer, while the life of the perfect fly lasts about three weeks at the same season. As cold weather approaches propagation ceases, and the older flies perish. A few of the more vigorous females, however, retreat to some nook or cranny where, in a state of torpor, they survive till the ensuing season—links 'twixt the summer gone by and to come. The insect may also hibernate in the pupa state in the ground, as I have found the puparia quite late in the fall. In rooms kept continuously warm, or in more southern latitudes, the fly remains active all winter, and our palace sleeping-cars bring them daily to us from Florida during the coldest months of the year.

I have no figures of the house-fly in its different states

with me, but they bear a general resemblance to those of the flesh-fly. (Fig. 9.)

Fig. 9.—*Sarcophaga sarracenia*: *a*, larva, *b*, pupa, *c*, fly, the hair lines showing average natural lengths; *d*, enlarged head and first joint of larva, showing curved hooks, lower lip (*g*), and prothoracic spiracles; *e*, end of body of same—showing stigmata (*f*) and pro-legs and vent; *h*, tarsal claws of fly with protecting pads; *i*, antenna of same—enlarged. (After Riley.)

You will notice that the larva tapers toward the head, which is retractile, and armed with two black hooks. It is blunt and truncate behind, and breathes principally through a pair of spiracles situated on this truncate, anal end.

While I must pass over the complicated mouth, the stereoscopic eyes, with their 4,000 facets, and many curious details in the structure of the fly, it will be well to dissipate two quite widespread popular errors in regard to it. Most of the old authors tell us that the fly walks on the ceiling, and in other ways defies the laws of gravitation, by suction. You will notice from the figure of the foot of the flesh-fly (and that of the house-fly has a similar construction) that it ends in a pair of strong hooks and a pair of pads or cushions, technically termed pulvilli. These were supposed to act as sucking disks by creating a vacuum, on the same principle as does the piece of circular leather used by school-boys for a similar purpose. In reality, however, these pads are beset with innumerable knobbed hairs, which are kept moist by an exuding fluid. In short, we have here a repetition, after a fashion, of the ambulacral suckers of the star-fish. The smoother the surface, the greater the adhesion of the digituli. This you will at once understand by gently pressing or drawing the moist finger ends over a glass window, or other polished surface. The adhesion is very sensible, whereas,

on a rougher surface like cloth or a whitewashed wall, there will be none.* On such surfaces the tarsal hooks, by catching in the minutest irregularity, take the place of the pads in assisting the fly's locomotion.

The other prevalent fallacy is that the smaller flies often noticed in our houses are young flies. In the fly, as in all other insects, real growth takes place only in the larva state. It ends with the issuing from the pupa and the expansion of the wings. Individuals differ in size at maturity just as they do in man and other animals, and various other species of Diptera are often associated with the house-fly, but they are all full-grown.

A word as to the fly's parasites. It has several. Probably the most common is the microscopic plant or fungus, (*Empusa musca*), which so often sheds a misty halo around it in autumn, and fastens it securely to the window pane; but the title to these remarks excludes its consideration in detail. A true internal parasite has been found in the puparium by Dr. Packard, the character of which puzzled him, but which is probably a rove-beetle (family *Staphylinidæ*.) and probably of the genus *Oleochara*, a species of which is known to be parasitic on an allied genus (*Anthomyia*) of flies. The parasite most noticed, however, is the little red mite which so often attaches to it near the base of the wings. Here you have it when first hatched, (Fig. 10,) and in the

Fig. 10.—Larva of *Trombidium muscarum*. (After Riley.)

six-legged or *Astoma* form, having been referred to that genus before its larval character was understood. After attaching to the fly its body swells and its legs get relatively

* Prof. E. D. Cope mentions that on this principle, even the *Amblystoma* we have just talked about climbs a plate of glass with great ease by adhering closely to its surface with the moist abdomen.

smaller until we have a mere bag, which finally falls to the ground, and there lies helpless for a few weeks, during which the mature form which I have described as *Trombidium muscarum*, and which has eight instead of six legs, develops under the *Astoma* skin. The spherical red eggs are laid in loose masses in the ground, and the young *Astoma*, upon hatching, crawls upon the first fly which offers it an opportunity.

To show the transformations I exhibit illustrations (Fig.

Fig. 11.—*Trombidium locustarum*.—*a*, mature larva when about to leave the wing of a locust; *b*, pupa; *c*, male adult when just from the pupa; *d*, female—the natural sizes indicated to the right; *e*, palpal claw and thumb; *f*, pedal claws; *g*, one of the barbed hairs; *h*, the striations on the larval skin. (After Riley.)

11) of an allied species (*Trombidium locustarum* Riley,) which similarly affects locusts or “grasshoppers,” and I would parenthetically remark that man is as much subject to annoyance from these red mites as are the fly and locust; for the irritating pustules so common in late summer and autumn on the limbs of persons who walk in rank grass or along rivers are caused by a minute red mite, (*Leptus irritans* Riley,) popularly denominated “Jigger,” and evidently the six-legged larva of some eight-legged form not yet ascertained.

PARASITISM.

This external parasitism in insects is, however, less remarkable than that which is internal.

If I should tell you that I know certain kinds of birds

which bore holes into the bodies of cows, sheep, and other herbivorous animals, and therein deposit eggs; that these eggs hatch into lizards; that these lizards grow fat at the expense of the sheep, but without immediately killing them; that, in fact, a sheep so affected could live without eating for years, where otherwise it would die in a few days without food; that the lizards in time leave the body of the sheep in numbers and burrow into the ground; and that, finally, after the lapse of an indefinite period, they issue forth in the form of birds like their parents, why, not one of you would believe me! But, it is only by drawing some such striking picture that I can hope to convey to you any correct idea of the remarkable facts of parasitism in the insect world. Most insects have primary parasites, but in some cases these are themselves preyed on by secondary parasites and these again by tertiary ones; so that a worm may be a peripatetic banqueting hall for several other insects at the same time.

To be more explicit and exact, let us take a familiar example. The typical female Ichneumon-fly has something

Fig. 12.—*Pimpla annulipes*: Outline side view of female and of male abdomen. (After Riley.)

of this form which I will draw on the blackboard, (see Fig. 12, *Pimpla annulipes* Br.) its chief characteristics being the long ovipositor with the two sheaths, possessed by the female but not by the male.

Let us take for examples the large Potato-worm or any other *Sphinx* larva with the horn near its end (which seems to have no other purpose than to frighten superstitious people who erroneously believe it to be capable of inflicting a poisonous sting,) and one of its commoner *Ichneumon* parasites belonging to the genus *Microgaster*. Our female *Ichneumon*-fly hovers about the worm while it quietly feeds. Settling finally on its back, generally behind the head where its mouth cannot reach her, she deliberately thrusts her ovipositor through the skin of her victim and oviposits within its body. Her young are soft, whitish larvæ which, upon issuing, spin upon the poor worm's back a number of egg-shaped cocoons (Figure 13,) often mistaken for eggs by the

Fig. 13.—Shrunk larva of *Cheerocampa pampinatrix*, with *Microgaster* cocoons. (After Harris.)

uninitiated. Within these the transformations are undergone, and the perfect flies cut a lid through the top of the cocoon and escape, sometimes while yet their victim shows faint signs of life. Now such a parasitized worm will drag out a paralyzed kind of existence without food for several weeks, where, normally, it would starve to death in as many days, and the parasite may, in its turn, be infested with a secondary species, etc., as above stated.

THE MOSQUITO.

There is another little lady whom you have fed and regaled at your own expense, and very unwillingly withal. She is by no means modest, but steals unbidden into your room. She generally heralds her coming with song that is anything but soothing, and she is so persevering that even the strong "bars" with which you protect yourself are not proof against her persecutions. You have all, no doubt, at times exercised a little strategy with the mosquito, and

when the little torment was fairly settled, made a dexterous movement of the hand, and with a slap exclaimed, "I've got him this time!" No such thing; you never got *him* in your life, but probably have often succeeded in crushing *her*, for the male mosquito is a considerate gentleman. In lieu of the piercer of the female he is decorated with a beautiful plume, and has such a love of home that he seldom sallies forth from the swamp where he was born, but contents himself with vegetal rather than animal juices. (I do not wish to make any reflections, but in the insect world it is always the females which sting!)

But to its history. The mosquito was not born a winged fly, and if you will examine a tub of rainwater that has stood uncovered and unmolested for a week or more during any of the summer months, you may see it in all its various forms. You may see the female supporting herself on the water with her four front legs and crossing the hinder pair like the letter X. In this support made by the legs she is depositing her eggs, which are just perceptible to the naked eye. By the aid of a lens they are seen to be glued together so as to form a little boat, which knocks about on the water till the young hatch. And what hatches from them? Why those very wrigglers (Fig. 14, *f*) which jerk away every

Fig. 14.—*Culex pipiens*: *a*, male; *b*, head of female; *c*, joints of male antenna; *f*, larva; *g*, pupa—all enlarged. After Westwood.

time you touch the water. They are destined to live a certain period in this watery element, and cannot take

wing and join their parent in her war song and house invasions, till, after throwing off the skin a few times, they have become full-grown, and then with another molt have changed to what are technically known as pupæ (*g.*) In this state they are no longer able to do anything but patiently float with their humped backs at the surface of the water, or to swim by jerks of the tail beneath, after the fashion of a shrimp or a lobster. At the end of about three days they stretch out on the surface like a boat, the mosquito bursts the skin and gradually works out of the shell which supports her during the critical operation. She rests with her long legs on the surface for a few moments, till the wings have expanded and become dry, and then flies away to fulfill her mission, a totally different animal to what she was a few hours before, and no more able to live in the water as she did then, than are any of us! Is it not wonderful that such profound changes should take place in so short a time? Even the bird has to learn to use its wings by practice and slow degrees, but the mosquito uses her newly acquired organs of flight to perfection from the start!

In this transformation from an aquatic to an aërial life, the mosquito has first breathed from a long tube near the tail; next through two tubular horns near the head, and, finally, through a series of spiracles along the whole body.

From a calculation, made by Baron Latour, the mosquito in flight vibrates its wings 3,000 times in a minute—a rapidity of motion hardly conceivable.

Those who have traveled in summer on the lower Mississippi or in the Northwest have experienced the torment which these frail flies can inflict: at times they drive everyone from the boat, and trains can sometimes only be run with comfort on the Northern Pacific by keeping a smudge in the baggage car and the doors of all the coaches open to the fumes.

The bravest man on the fleetest horse dares not cross some of the more rank and dank prairies of Northern Minnesota in June. It is well known that Father De Smit once

nearly died from mosquito bites, his flesh being so swollen around the arms and legs that it literally burst.

Mosquitoes have caused the rout of armies and the desertion of cities, and I would counsel all who desire to learn how the hum of an insignificant gnat may inspire more terror than the roar of the lion, to consult Kirby and Spence's history of the former.

There are many species of the mosquito, all differing somewhat in habit and season of appearance, and doubtless also in mode of development, which, in fact, has been studied in but few. They occur everywhere, whether in the torrid or the arctic zone, and are nowhere more numerous or tormenting than in Lapland.

Both the fly and the mosquito are great scavengers in infancy, the one purifying the air we breathe, the other the water we drink. They perform, in this way, an indirect service to man which few, perhaps, appreciate, and which somewhat atones for their bad habits in maturity.

THE EARTH-WORM.

The next well-known animal that I shall speak of is the earth-worm. There are several species in different parts of the world and I am not aware that any one has critically determined our common North America species to be the *Lumbricus terrestris* of Europe, which, however, we will, as others have done, assume it to be. It belongs to the great branch *Vermes*, of which it is typical, and its general habits are too well-known to need detailing. If you have ever had occasion to catch worms for some pet bird or for baiting purposes, you have learned that this creature is by no means so sluggish and weak as is commonly supposed, for it can retreat within its burrow like a flash and can secure such a firm hold therein as to almost defy extraction intact. Place one upon your hand and its movements will cause a slight tingling roughness. Examine the body with a lens and you discover that each of the numerous rings or joints into which it is divided is furnished with four pairs of minute tractile hooks or points which take the place of legs and by means of which its movements are aided, and it is enabled to hold

to its burrow as above indicated. The earth-worm is hermaphrodite. Yet the junction of two individuals is necessary to liberate and fructify the ova. At certain seasons a few of the rings, generally near the anterior third of the body, swell so as to look much like a healing wound. Two individuals join at these swollen parts, a glutinous secretion aiding the conjugation.

Fig. 15.—*Lumbricus terrestris*: *a*, worm with pale, swollen rings; *b*, two conjoined; *c*, egg, natural size; *d*, do., enlarged, (after Curtis;) *e*, a few rings; *f*, transverse section, showing spines, enlarged. (After Samuelson.)

The young worm is born much like its parent, either free or in a cyst-like covering, which subsequently bursts—the nature of the soil having apparently something to do with the difference. In some species a number of eggs are enclosed in a single capsule. The worm, though living in the earth, is really semi-aquatic. It will live a long while in water, but soon dies when exposed to the dry air. It delights most in damp soil, and takes advantage of rains to travel at night on the surface, and in early spring it is often allured in great numbers on to the warm pavements of our city, where many perish if the weather becomes suddenly cold or the pavement dries out too rapidly. The earth-worm hibernates at the bottom of its burrow, which may extend from three to six feet in a light soil; it also remains coiled up in a state of torpor during very dry weather. It is by no means devoid of sense or intelligence; but it is as an agent in indirectly promoting man's welfare that this humble creature performs a part that few suspect. The same genius who so profoundly influenced modern scientific thought by the

"Origin of Species," has recently given us a treatise on the earth-worm, wherein its important work is admirably set forth. Worms are in reality the original tillers of the soil, and the present mold-builders of the world. Darwin proves the correctness of the position he maintained some forty-five years ago in a paper read before the Royal Geographical Society of London, viz: that "the farmer is only imitating in a clumsy manner, without being able to bury the pebbles or sift the fine from the coarse soil, the work which nature is daily performing by the agency of the earth-worm." By their castings they have been known to raise a field 13 inches in 80 years, and they have not only helped materially in burying small superincumbent objects; but have, according to Darwin, played an important part in the burial of ancient buildings. The celebrated seedsman, Mr. J. J. H. Gregory, of Marblehead, Mass., carefully collected the castings daily for one season over a given area, and they measured nearly a quart to the square foot, or enough to raise the surface of the land half an inch. He also, by experiment, shows that an acre of land may contain six tons of worms; Von Hensen estimated 53,767 worms to the acre, and that they would make 37 pounds of mold every 24 hours. As agents in aiding denudation they are also powerful.

Who, remembering the gigantic work performed by the coral polyp in transforming, so to speak, ocean into land—the important part it has played in the configuration of continents, can doubt the wonderful services of the earth-worm as Darwin has so forcibly presented them? In some respects he has, perhaps, underrated the results of frost and of atmospheric dust and deposit, in burying objects and increasing superficial soil, and I am inclined to think that the value of worms from the agricultural standpoint is overrated, since they are a well recognized nuisance in lawns and pots,* tend to deaden the soil where excessive, and do not occur in the very soils that most need the digested humus or decomposing vegetation which they cast up; but allowing this, the

* Grated horse-chestnut or lime mixed in the soil will relieve the same of worms.

worms' part in the history of the world, and in a geological sense, is still amazing.

There are, indeed, very good reasons for believing that all genuine loam is produced solely by worms.

“ Think naught a trifle, though it small appear ;
Small sands the mountain, moments make the year,
And trifles life ! ”

And now, ladies and gentlemen, the limit of time which custom and a due regard for your feelings have established for these lectures has been reached. I had hoped to say something of the scale-insects which are so common and destructive on our fruit trees and other plants, and which give us the lac and the cochineal of commerce as they gave the manna to the people of Israel ; to show you how perfect a parallelism may be traced in the history of some of them and that of the oyster:—the active young ; the degradational development ; the formation of the shell ; the way it is perforated by parasites, etc., offer a remarkable instance of the existence of that misleading analogy of function which Prof. Gill so ably dealt with, in creatures which belong to different branches of the animal kingdom, and which possess no possible homologies with each other. I had hoped to give you some details of the remarkable hyper-metamorphoses and life-habits of the blister-beetle, of which we annually import large quantities under the name of cantharides, when we have a number of indigenous species with as good or better vesicatory properties. But, above all, I wanted to treat of the butterfly, for if the transformations of the animals I have already spoken of are remarkable, those of the butterfly from the caterpillar, through the chrysalis, transcend them all, and have always excited the greatest curiosity and wonder ; while the feat which the caterpillar in some instances performs in the change to the suspending chrysalis is really marvelous, and was first properly explained, a little more than two years ago, before the Philosophical Society of this city. I have been able only in the most imperfect manner to treat of the more salient facts in the lives of some half dozen of the numerous ani-

imals familiar to all, and if I have succeeded in investing these with a new interest in your eyes, the effort will not have been in vain. I beg to assure you, also, that there is no reflection in the assumption that you knew little of some of the facts stated, because, in truth, several of them have but very recently been learned by naturalists, and every year's investigation adds something to the general store of knowledge in natural science.

In closing, permit me to offer a few thoughts that seem naturally to flow from the matter of this lecture. We have seen that in every one of the great Cuvierian Branches of the animal kingdom—even in that which contains man—surprising development, profound metamorphoses, are undergone during the life of the individual. From the maggot to the fly : from the tadpole to the frog, astounding changes take place in form, structure, and adaptation to surroundings within a few days or months, and before our very eyes. We have seen how mighty results may follow in time from the slowly-accumulating yet scarcely perceptible labor of so seemingly insignificant an object as the earth-worm. With such facts before you can you doubt that changes like those experienced by the individual in so short a time may have been experienced by the race in unlimited time. Can you longer wonder when nature thrusts upon him at every turn such and a thousand other evidences of development that the evolutionist believes in it as a principle—a law—the only mode of creation ! It permits us

“ To paint the past, yet in the past portray
Such shapes as seem dim prophets of to day.”

and had not paleontology recently given us absolute proof of its truth, evolution, even as a mere conception of creation, infinitely transcends all former conceptions. The tree grows from the root upward, not from the leaf and flower downward. Man has grown up from a past savagery, not from perfection downward. Were I to assure you that you were all created full-bearded and full-dressed by some miraculous fiat, instead of having been born of parents and

developed from infancy through childhood to maturity, you would flout the assertion as that of a crazy man. Yet I do assure you that the similar miraculous creation of a species out of nothing so persistently believed in by many even to-day, appears not one whit less absurd to the well-informed naturalist.

In reflecting on what I should say to you to-day, I found this question constantly running through my mind: "Why is it that so little is known in the most intelligent communities of the commonest things around them?" It is, I take it, because, first, the teaching of natural science is so generally neglected in our public schools and other educational institutions. The child is taught something of the elephant, the lion, the tiger, and of other tropical quadrupeds which it is rarely destined to see except in some menagerie, and nothing of the many that it meets with in every day life; so that many a man is inclined, with Carlyle, to lament in after-life that no schoolmaster of his had taught him the grasses that grow by the wayside and the little neighbors that are continually meeting him with a salutation which he cannot answer as things are. The importance of things is too often measured by their size. Yet the unseen worlds in the starry firmament which the astronomer explores with his telescope are no more marvelous than the unseen minims of creation which the naturalist may explore with his microscope! What is true of animals is true of plants and of all other organisms. Happily much progress has been made in this direction during the past few years, the tendency of the times being strong in the direction of more science in our schools; in other words, of that education that will give more perfect knowledge of ourselves and the world we live in.

Education should be a living thing, animated by modern impulses, molded by modern thought, and governed by modern wants, and I think the people of the country are to be congratulated on the establishment of this National Museum, which is founded on so broad a bases that it cannot fail to exert a marked influence in promoting such education as I have indicated.

Again, the ordinary man of affairs is very apt to look upon the study of natural science as trivial because of no possible use to him in his business. The cry of *cui bono* is constantly raised against it, but on equal grounds it might be raised against history, polite literature, and many other studies. To those—if such there be among my auditors—who take so narrow a view of the subject, I would say that to the larger portion of our population, which represent the agricultural industry on which all our prosperity as a nation depends, a knowledge of natural science is of the utmost practical value, while to all it will afford both health and pleasure as a recreation from the care and grind of business life. In this country, more particularly, the mind of busy man finds no relief in idleness, and on all sides we see men who, indifferent alike to the noblest works of art and the sublimest teaching of nature, accumulate fortune only to find that they are physical wrecks and mentally incapable of deriving pleasure or stimulus from anything but still further accumulating—slaves, in fact, to a sordid habit. How many women, also, drift into a Sybaritic life and come to find relief from *ennui* only in one constant round of artificial pleasure which ends too often in mental and physical misery. There is no better prophylactic against such dangers; no surer cure for that *tedium vite* which haunts so many, than the study of natural science. There is an inexpressible charm in animated nature for those who have learned to unlock her secrets. They, indeed, “find tongues in trees, books in the running brooks, sermons in stones, and good in everything.” They see everywhere around and about them—in earth, air, sky, and water—volumes inspired by the great author of our being; significancies, harmonies, causes and effects that give glimpses of the very thought of the Creator. In Williamson’s words: “Those who have the power of understanding the wonders of nature derive great happiness from learning to employ it. It is like the pleasure which a man of healthy and vigorous frame experiences in climbing a mountain peak, and in en-

joying, in proportion as he rises, a wider and more commanding view of things below."

" This is human happiness !
 Its secret and its evidence are writ
 In the broad book of nature. 'Tis to have
 Attentive and believing faculties,
 To go abroad rejoicing in the joy
 Of beautiful and well-created things ;
 To love the voice of waters, and the sheen
 Of silver fountains leaping to the sea ;
 To thrill with the rich melody of birds,
 Living their life of music ; to be glad
 In the gay sunshine, reverent in the storm,
 To see a beauty in the stirring leaf,
 And find calm thought beneath the whispering trees ;
 To see and hear and breathe the evidence
 Of God's deep wisdom in the natural world ! "

I hope I have said enough to show that deep insight into Nature's truths is not only of practical value, but that it is in other ways beneficial and elevating. Nor is it satiating ! One never tires of the recurring seasons, and one never tires of any scientific research, for the simple reason that there is never any end, but always something new to learn—something more wonderful to unfold.

Says Lowell :

I grieve not that ripe knowledge takes away
 The charm which Nature to my childhood wore,
 For with the insight cometh day by day,
 A greater bliss than wonder was before.
 To win the secret of a weed's plain heart,
 Reveals the clue to spiritual things ;
 The soul which looks within for truth, may guess
 The presence of some unknown heavenliness !

PAUL BROCA

AND THE FRENCH SCHOOL OF ANTHROPOLOGY.

Lecture delivered in the National Museum, Washington, D. C., April 15, 1882.
by Dr. ROBERT FLETCHER.

LADIES AND GENTLEMEN:

You have heard a great deal in these latter days of the Science of Anthropology, and while many of you, doubtless, have been following its investigations and discoveries with interest and profit, others will be prompted to inquire: What is Anthropology, and when, and by whom, was it discovered or invented? To the first part of the question it is unnecessary for me to reply, as Professor Mason, in the second lecture of this course, gave a lucid exposition of what constitutes the science in question; but the reason of its existence, and the circumstances attending its establishment and recognition in the scientific world, it is the purpose of this lecture concisely to explain.

Taking a comprehensive view of the subject, it would be correct to say that anthropology has existed since the earliest days of human civilization. Classical literature shows us Strabo and the geographers describing races—ethnographers; Galen and his followers as anatomists and physicians—biologists, as we should call them now; and Plato and the metaphysicians as psychologists. We go back to Justinian for the first records of an important branch of sociology, the origin of law, and the technologist cannot afford to overlook Vitruvius and Vegetius in tracing out the early history of tools, arms and weapons. But it is not with the separate sciences which together form what we now call anthropology, tempting as the subject is, that we have to do, for the theme is much too vast for the time at our disposal.

I must remind you that the term itself has been used with very different meanings by the theologian, the anatomist, and physician. "Journals of Anthropology," of which there were many in Germany a hundred years ago, were mostly devoted to medicine and surgery. Its use in its present comprehensive sense arose with the establishment

of the Paris Society of Anthropology, about twenty-five years ago, and its fitness for the purpose was so manifest that it has superseded to a great extent the narrower titles of ethnology and archæology. At the present day there are Societies of Anthropology in nearly all the capital cities of the world. They were all founded, more or less, upon the model of the Paris society, which is acknowledged as the parent from which this flourishing progeny has sprung.

It will be more convenient for our purpose to begin with a description of these associations as they now exist, and then, in a brief biography of the eminent Frenchman who founded the Paris society, show you in what manner the science of anthropology received its birth and baptism.

The first French Society which made the study of mankind the especial object of its enquiries, was founded in Paris in the year 1800, and was known as *La société des observateurs de l'homme*—the Society of Observers of Man. From their programme, and from the meagre reports of their transactions which appeared from time to time in the *Magasin encyclopédique*, it is evident that the natural history of man chiefly occupied their attention. In 1803, this association was united with The Philanthropic Society (*La société philanthropique*) and lost its scientific identity. In 1838, there was founded in London, under the presidency of Sir Thomas Fowell Buxton, the leader of the party advocating the abolition of slavery in British dominions, a Society for the Protection of the Aborigines. The object of this association was political and not scientific, but one of its members, a Mr. Hodgkin, visited Paris a year later for the purpose of establishing a French society on the same basis, and came into communication with many eminent men, among whom was the celebrated naturalist, William Edwards. The attempt to found a French abolition society failed, but the interest excited in the cognate subject of race led Edwards and his friends to establish the Ethnological Society of Paris, (a,) whose existence was officially authorized by the Minister of the Interior, in August, 1839. This society published two volumes of memoirs, and one, of its

transactions. The work it achieved was excellent in kind, but its membership was never large, and no great degree of zeal was evinced by those belonging to it. In 1842, the American Ethnological Society (*b*) was founded by Albert Gallatin, and in 1844, the Ethnological Society of London (*c*) was established, both after the model of the French Society.

Possessing no museum for the accumulation of specimens, the Ethnological Society of Paris devoted itself mainly to the investigation of certain races, their habits and customs. Unfortunately, too, for its prosperity, it took up with great heat the subject of slavery, which was being fiercely debated in France in the years 1847-8. The society was interested only in the question of race, and of the single or multiple origin of mankind, but an absurd belief became general that ethnology was, in some mysterious manner, another name for abolitionism, and this prejudice survived to be an obstacle in the establishment of the Anthropological Society, ten years later.

What the circumstances were that led to the foundation of the latter society, through what discouragements and obstructions it forced its way onward, and what success was at last achieved, will be described in the biographic sketch of Broca which will be presently attempted.

The time was ripe for the undertaking. The society was established in 1859, (*d*), and in the years immediately preceding rapid advances had been made in the various branches of knowledge which constitute anthropology. In England, Davis and Thurnam had begun their great work, the *Crania Britannica*; in Sweden, Retzius was carrying on his remarkable studies in craniology; Morton, of Philadelphia, having amassed the collection of skulls which was, for many years, the richest craniological collection in the world, had produced his important work, the *Crania Americana*. Boucher de Perthes, after eighteen years of labor in the quaternary deposits of Abbeville, had at last triumphed over ridicule and malice, and had seen his proofs of the great antiquity of man accepted by the leading paleontologists of the world. In Denmark, the Kitchen-middens,

those silent chronological records of the devouring appetite and progressive luxury of primeval man, had been explored and described by Worsäae and Thomsen. In Switzerland, the unusual subsidence of the waters of the lakes had brought to light the relics of the lake-dwellers; and, not less memorable, on the 24th November, 1859, there appeared in London a modest looking volume which has probably exerted more influence on scientific workers than any one book ever published—its title was: *The Origin of Species*, by Charles Darwin.

Prof. Huxley, speaking of this occurrence twenty years later, said:

“It was only subsequent to the publication of the ideas contained in that book that one of the most powerful instruments for the advance of anthropological knowledge—namely, the Anthropological Society of Paris—was founded; afterward, the Anthropological Institute of this country and the great Anthropological Society of Berlin came into existence, until it may be said that, now, there is not a branch of science which is represented by a larger or more active body of workers than the science of anthropology. But the whole of these workers are engaged, more or less intentionally, in providing the data for attacking the ultimate great problem, whether the ideas which Darwin has put forward, in regard to the animal world, are capable of being applied in the same sense, and to the same extent, to man. That question, I need not say, is not answered.”

It may seem almost superfluous to explain the allusion to the lake-dwellings and the kitchen-middens, but some of the younger members of this audience may be glad to learn what is meant by those terms.

In Switzerland the winters of 1853 and 1854 proved to be so dry and cold that the usual spring freshets in the rivers were wanting, and the level of the water in the great lakes was lower than had ever before been recorded. Accident led to the discovery of some ancient piles, and other evidences of man's work. The result of long-continued investigations may be briefly stated, as follows: The *Pfahlbauten*, or pile-works of Switzerland, were villages built on piles

driven into the water on the edges of the lakes. They communicated with the land by one or more bridges, and there is no doubt that defence against wild animals as well as human enemies was the motive for this method of erecting habitations. The debris of the household necessarily fell into the water, together with tools, weapons and ornaments, and thousands of such articles have been recovered from the soil of the lakes around these piles, together with the bones of animals which had served for food. The larger number of these pile-works were erected during the stone age, before the use of metal was known to man; but in Western Switzerland the remains belong to the bronze age, vast numbers of bronze implements and ornaments having been recovered from them. From one settlement alone 500 bronze hair-pins, such as peasant women adorn their hair with, were obtained. Troyon has made an estimate of the population of these lake-dwellings; his figures are 32,000 for the stone age, and 42,000 for the bronze period. The addition to our knowledge of pre-historic man obtained from these Pfahlbauten has been of incalculable value.

Accident, in like manner, drew attention to the real import of certain shell-heaps in Denmark. They had been regarded as raised beaches, the results of upheaval; but with such an origin the shell-fish must necessarily have been of kinds which would live together. They would be of all sizes, and would be mixed with sand and gravel. In the shell-heaps—now known as kitchen-middens, from the Danish Kjøkkennødding, kitchen-refuse heaps—the shells are nearly all of full-grown individuals, and of kinds which do not live together, and no sand or gravel was found in them. Flint implements and bones of animals, birds and fishes abound in them, and it became evident that these shell-heaps had been sites of villages of neolithic man, and that the shells and other remains had accumulated in consequence. Results as interesting as those obtained from the exploration of the lake-dwellings followed, and the museums of Copenhagen are rich with the spoils of the kitchen-middens. Similar shell-heaps have been found in almost all countries.

It was under the auspices thus outlined that the Society of Anthropology of Paris began its career. Its success was assured as the quality of its work became known, and within ten years, in all the chief kingdoms of Europe, societies of like purpose were organized, and are in the full tide of prosperity and active occupation at the present day.

And here it may be well to explain why the term "ethnology" has been so generally superseded by the term "anthropology." The former, as you are aware, is the science which treats of the races of men. Linnæus and Buffon were its chief founders, but Blumenbach moulded it into the shape which it yet preserves. It is to him that we owe the five divisions of the human race which still maintain their place in our school-books, though they have long since been discarded from scientific description. Ethnology classifies mankind according to certain resemblances of features, color, hair, dress, weapons, and the like; anthropology takes his anatomical structure as the basis of comparison. Broca, speaking of the two, says: "Ethnologists regard man as the primitive element of tribes, races, and peoples. The anthropologist looks at him as a member of the fauna of the globe, belonging to a zoölogical classification, and subject to the same laws as the rest of the animal kingdom. To study him from the last point of view only would be to lose sight of some of his most interesting and practical relations; but to be confined to the ethnologist's views is to set aside the scientific rule which requires us to proceed from the simple to the compound, from the known to the unknown, from the material and organic fact to the functional phenomena."

You were told in a preceding lecture that ten distinct sciences were included under the name of anthropology; ethnology, much shorn of its significance, being one of them. You will see then that the more comprehensive term was necessary to indicate the scope of the investigations pursued.

I propose next to give you a succinct account of the societies which were founded after the model of the Paris association.

In 1861, Rudolph Wagner of Göttingen and DeBaer of St. Petersburg organized a German Anthropological Association, (*e*.) which was to meet every second year in a German city. Its first meeting was held at Göttingen, but the death of Wagner, which took place soon after, interrupted its further progress.

In 1863, arose the Anthropological Society of London (*f*.) It was formed by the secession of a large number of members of the Ethnological Society, and speedily became so successful that it at one time numbered 800 members. It continued to exist under its original title until 1871, when the Ethnological Society consented to unite itself with its ambitious offspring and the designation assumed by the united associations was: The Anthropological Institute of Great Britain and Ireland (*g*.) The Ethnological Society published 13 volumes of Transactions; the Anthropological Society published 9 volumes, and the Journal of the Anthropological Institute has now entered on its twelfth year.

In 1865, the Anthropological Society of Madrid (*h*) was established, its first meeting being held on December 17. Owing to political complications, so common in that unhappy country, and to the opposition of the priesthood, no further meetings were permitted, and the Society, which had attained a membership of 300, continued in a languishing condition until February, 1869, when its second meeting took place.

In Moscow, in 1866, the Society of the Friends of Nature (*i*) established a section of anthropology. Endowed with ample revenues this section has been as efficient as if it had been an independent society. It possesses a valuable museum and, in 1867, a brilliant exposition of anthropology took place under its management.

In 1868, the Berlin Society of Anthropology (*k*) was organized and speedily attained foremost rank from the importance and extent of its investigations. Virchow, the illustrious physiologist, statesman and scholar, still presides over its meetings. The Society publishes the Journal of Ethnology.

In 1870, the Anthropological Society of Vienna (*l*) was founded, and at their first meeting, February 13, the opening address was delivered by Rokitansky. The Society publishes its own transactions.

Italy was next to continue the good work, and, in 1871, was established the Italian Society of Anthropology and Ethnology (*m*.) Their transactions are reported in the Archives of Anthropology and Ethnology, a monthly journal, handsomely illustrated, which is published at Florence under the editorship of Mantegazza.

In 1871, in the city of New York, there was founded a society known as the Anthropological Institute of New York (*n*.) Its sole work was the publication of its Journal, "Whom the Gods love, die young," says the Greek proverb: the "Journal of the Anthropological Institute of New York" must have been the especial object of celestial regard as it expired with its first number.

In 1877, Poland entered the field, and the Academy of Sciences of Cracow (*o*) established a section of anthropology which publishes its own journal.

In 1879, the Anthropological Society of Washington, D. C., (*p*.) was founded, and has continued to thrive.

During the present year, Dr. Aurèle de Torok, of Hungary, who had been for some time studying at the Paris school, was placed in charge of a section of anthropology in the University of Buda-Pesth, with instructions to form a museum.

There are many subordinate societies besides those described; they are generally affiliated with the societies of the capitals. For example, there is an Anthropological Society at Liverpool, another at Oxford, another at Manchester; one at Lyons, one at Bordeaux, and even in the Isle of Man there is a section of anthropology in the Manx Society of Sciences.

Another important result of the interest felt in these pursuits has been the organizing of congresses of anthropology, meeting in different cities at stated intervals.

There is the German Association for Anthropology (*q*)

founded in 1870; their first meeting was held in Berlin, and their transactions appear in a goodly quarto, the Archives for Anthropology, published at Brunswick.

But the most important congress, in view of its achievements, is the International Congress of Anthropology, and Pre-historic Archaeology (*c.*) Their first meeting was held at Neufchatel in 1866; the second at Paris in 1867; the third at Norwich, England, in 1868; the fourth at Copenhagen in 1869; the fifth at Bologna in 1871; the sixth at Brussels in 1872; the seventh at Stockholm in 1874; the eighth at Buda-Pesth in 1876; and the ninth at Lisbon in 1880. I believe the next meeting is to be held at Venice this year. The transactions of this association are published after each congress.

Finally, it must be added that the British Association for the Advancement of Science, after much contention, has established a section of anthropology. The French Association of the same name began with such a section as part of its original organization.

I have no doubt that my hearers are reasonably grateful that this dry enumeration of societies and their productions has come to an end; but it has been shown that all of these associations, congresses and sections owe their origin to the Paris School of Anthropology, and as that school, in its turn, derived its very existence from the genius and energy of one man, we are brought naturally to the point where a sketch of the life and work of the founder of European anthropology comes properly into our plan.

Pierre Paul Broca was born at Sainte Foix-la-Grande, in 1824. The town which announces itself to the world under this pretentious title is situated in the department of the Gironde, on the bank of the Dordogne, forty miles from Bordeaux, and contains about 4,000 inhabitants. It was the birthplace also of Gratiolet, distinguished, like Broca, in anthropology as well as in medicine.

It is always interesting, and, indeed, essential to the due estimation of a distinguished man, to state what may be

known of his parentage, and of what it is now the fashion to call his early environments.

Broca's father, Dr. Benjamin Broca, was an army surgeon, and had served throughout the memorable war in Spain under the first Napoleon. The campaigns over, he returned to his native town where he married and settled down to practice his profession. He was a man of marked traits of character; of unflinching probity and courage, and charitable to an extreme. From him his son derived his taste for the natural sciences as well as a grave irony which characterized them both. The son used to quote an ironical remark of his father's which is amusing enough to be related. The elder Broca flourished in the time when the doctrines of Broussais attained such astonishing popularity, and blood-letting and rigorous diet were the treatment in vogue. Against these views, Dr. Broca fought valiantly, and it is told of him that after a consultation over a patient prostrated with typhoid fever, hearing the physician in charge prescribe, as the only nutriment, a broth to be made of frog's feet, Broca turned back from the doorway and said, "and above all things, be sure to skim off the fat!"

Dr. Broca, senior, acquired a large country practice, but which was not very lucrative, for his rule was to charge the rich but little, while to the poor he gave his services and paid for their medicines. When, in later years, after the death of his wife, he removed to Paris to reside in the house of his distinguished son, the whole country round was in sorrow for his loss, and his indigent clientage presented him with a silver-gilt cup inscribed "To the physician of the poor."

An amusing story is still told in Sainte-Foix of this excellent man which exemplifies his unfailing benevolence. At a late hour, one cold and dark winter night, a peasant requested him to visit a person taken seriously ill, in a distant hamlet. The good doctor left his comfortable fire-side without hesitation and accompanied the man along a lonely pathway, inaccessible to all but pedestrians. Arriving, at length, at a small cluster of cottages, the man turned

to him and said, "Many thanks, doctor. You see I was afraid to come along these lonely beaches by myself, in the middle of the night, so I invented the little story of the sick person to get you to come with me; much obliged for your company." And the fellow disappeared in the darkness, leaving the doctor to return as best he could.

I have been told by Dr. Ford Thompson of this city that when in Paris attending the clinique under Professor Broca at the hospital of La Pitié, he was struck with the appearance of an aged gentleman who, with edifying punctuality, formed one of the large class which followed the professor through the wards. This venerable man would listen with equal interest and admiration to the luminous explanations, the subtle diagnosis, or the fecund illustrations which the accomplished surgeon would give utterance to, at the bedside. This was Dr. Broca, the father, finding his chief enjoyment, in the evening of his days, in watching the daily work of the son who had so far outstripped him in fame.

Broca's mother was the daughter of a Protestant preacher, named Thomas. She was an excellent woman, of great intelligence, and endowed with a prodigious memory. This latter quality was inherited by her son. The Brocas were of old Huguenot stock, and traditions were rife among them of the persecutions which the grandfather and great-grandfather had suffered in the days of the *dragonnades*.

There is no doubt that his early training by the kind, manly father and the clear-sighted sensible mother, together with the traditions of their family history, bred in the young Paul the courageous love of truth and hatred of injustice and oppression which marked his entire career.

In 1832, he entered the college of Sainte-Foix which was, at that time, the resort of the élite of the Protestant youth of France. Some of the most distinguished men of the reformed church were educated at Sainte-Foix; among whom were Monod, Coquerel, and Pressensé. When seventeen years old, Paul Broca obtained the three diplomas of bachelor of letters, mathematics, and physical sciences. In 1842, he presented himself for examination at the Polytechnic

School, intending to make physical sciences the basis of his future work, but his father, loth to see his own practice lost to the family, persuaded his son to adopt medicine as his profession. An additional motive for his compliance was the recent death of his only sister, a very lovely girl of great promise, whose loss made the parental home very lonely. Broca did not trouble himself about his career; he used to say, in after life, that in any occupation, he could have made such a place as his abilities merited; and with his healthy organization and unparalleled capacity for work, it is probable that he was right.

He went to Paris, and entered his name at the Faculty of Medicine, and thus began a career unequalled for the rapidity of its progress. In 1843, he became an *externe* at the hospitals, and in 1844, he became an *interne*. He was then twenty years of age, a period at which most students of medicine have only entered themselves. In 1848, he became prosector of anatomy, and obtained the silver medal of the Public Assistance. He graduated as Doctor of Medicine in 1849; the Academy of Medicine decreed him the Portal prize in 1850, and, in 1853, he was named Assistant Professor of the Faculty of Medicine, and Surgeon of the Central Bureau, being then only twenty-nine years old.

In 1847, he was elected a member of the Anatomical Society of Paris, and for many years he was the most active of the distinguished young men who raised that society to its present pre-eminence. His researches into the histology of cartilage and bone, with the aid of the microscope, of the use of which in anatomical researches he was one of the strongest advocates, have remained unsurpassed of their kind to the present day.

In the Society of Surgery he was equally active, and its transactions bear witness to his zealous labors.

It is not within the scope of this lecture to describe his surgical or physiological work; the general result, in the number of his productions, will be given at the close. It must be said, however, that his brilliant investigations into the localities of the functions of the brain led the way to

the discoveries and applications of Hitzig, Ferrier, and Charcot; of his larger works, the *Treatise on Tumors*, and the *Treatise on Aneurisms*, still hold foremost rank. Broca's devotion to anthropological studies, during the last twenty years of his life, have tended to overshadow his work in surgery and physiology. A good judge said of him, that in no country or age had any man of thirty produced so much of value in surgery as he.

He was associated with Beau and Bonamy in the production of their splendid *Atlas of Descriptive Anatomy*, and the third volume of that work, comprising splanchnology, is entirely his work.

It is scarcely necessary to say that this brilliant commencement of his career soon settled the question of his return to the banks of the Dordogne. The father was proud of his son's success, and the good mother, when told of his achievements, sacrificed her own wishes, as mothers do, and said, "my pride is gratified, but not my heart."

Honors continued to flow in upon him. He was made secretary and then vice-president of the Anatomical Society; secretary and then president of the Society of Surgery. The Academy of Medicine admitted him in 1866; he was their vice-president in 1880, and president-elect for 1881. In 1867, the Faculty of Medicine appointed him to the chair of pathology which he exchanged for that of clinical surgery.

It remains now to speak of Broca's connection with the Society of Anthropology of Paris. He was its founder and, in the words of one of his panégyrists, "the very soul of it for one and twenty years."

In 1847, he was one of a commission appointed to examine the bones discovered in excavations made in the ancient church of the Celestins. In drawing up this report, (which was afterwards published in the first volume of his *Memoirs on Anthropology*.) he was led to read all the books he could find, and they were not many, upon the subject of craniology. In those days ethnology was confined to a narrow circle of inquiry, chiefly to debates upon mon-

ogeny and polygeny, or the doctrine of the origin of the human race from one source or from many. The Ethnological Society of Paris, founded, as I have before stated, by William Edwards, having ended its discussions upon this subject, and finding nothing more to say, itself came to an end in 1848. Ten years later, Broca, who had arrived at some conclusions upon human hybridity which he desired to make known, communicated them to the Society of Biology. But the young discoverer had yet to learn what pusillanimity could do to retard investigation. His remarkable memoir demonstrated the unlimited fecundity of human hybrids, and as this was opposed to the doctrines of the monogenists, Rayer, the President of the Society, requested Broca to desist from further communications. The memoir "On animal hybridity in general, and on human hybridity in particular," was published in the *Journal de la physiologie*. It was afterward translated by Dr. Carter Blake for the London Society of Anthropology, and was published in their memoirs. This condition of things made it evident that a new society was needed, and Broca conceived the idea of a Society of Anthropology.

Broca's plan was to start with not less than twenty members. Six from the Society of Biology joined him, but others, including the members of the defunct Society of Ethnology, turned a deaf ear to his solicitations. After a year's efforts, he had only nineteen signatures, including his own. He met with every obstacle from those in authority; M. Rouland, the Minister of Public Instruction, sent him to the Prefect of Police, who, in turn, sent him to the Minister of Public Instruction. Their purpose was to weary him out, for with the perspicacity usual in such functionaries, they firmly believed that the novel term, anthropology, covered some form of political conspiracy. Finally, thanks to the intervention of Professor Tardieu, a chief of division of the prefecture of police was induced to authorize the nineteen to form their society and hold meetings. He held Broca, however, personally responsible for anything which might be said by his associates which should appear to be an

attack upon government, religion, or social order; and, to ensure the realization of these prudent precautions, he directed that a police officer, in plain clothes, should attend each meeting and report to the prefect the tenure of the proceedings.

Does not this sound as if we were discoursing of something that took place under Louis quatorze, or Philip the second? And yet it occurred in our own day, some twenty years ago, in the most civilized city of Paris. We are accustomed to look upon our own absolute freedom in such affairs as a matter of course, but it may not be unprofitable to occasionally stop to consider it in the light of comparison.

It was under the conditions described that the Society of Anthropology of Paris held its first meeting, on the 19th May, 1859. The word anthropology was substituted for ethnology to show the far wider scope proposed. It included, in effect, the entire natural history of the human race, whether in the present, in the past, in its general characters, in its subdivisions into races or varieties, in its origin, or in its relations with the rest of nature. This programme comprehended not only ethnology, or the study of human races, but anthropology, or the study of mankind. It included, also, a great number of auxiliary sciences: zoology, comparative anatomy, geology, paleontology, prehistoric and protohistoric archaeology, linguistics, mythology, history, psychology, and medicine itself. And as among all these diverse and divergent studies it was necessary to establish some central basis, the founders of the society, who were all young physicians, determined, in accordance with the views of their leader, to select that which is most fixed in man, namely, his organization and functions; in a word, his anatomy and physiology.

With such a vast field before it, there was no reason to fear that the new society would perish for want of sustenance like its predecessor, the Society of Ethnology. As its programme became known, new members eagerly joined it, and when the first volume of its bulletins was published, the defiance and distrust which it had excited rapidly sub-

sided. M. Rouland, the Minister of Public Instruction, deigned to authorize it in 1861, and, in 1864, it was recognized formally as a society of public utility, by a decree of the Council of State. After this date, the attendance of the special police agent at its meetings was discontinued.

During the first three years of the existence of the society, Broca filled the office of secretary. It was a burdensome task for a man of his numerous avocations to undertake, but it was of the highest importance that the transactions of the young society should be edited with talent and appear with punctuality. He excelled in the difficult art of giving the integral meaning, but without prolixity, of what was said in the ardor of debate. He was skillful in ignoring the common-places of the chronic speaker; the man who always "rises to give his views," though he has generally nothing to communicate. These *comptes rendus* are master-pieces of their kind, especially when it is considered that they were written from memory, for he took too active a part in discussion to have time to take notes.

In 1863, the increase of the Society made it necessary to appoint a General Secretary, electable for three years; Broca held the office till his death. Professor Pozzi says, "Broca was the soul of the Society of Anthropology. It was he who founded it, he who made it live through its first trying years, and that by the preponderating influence of his incessant labor and the communicable ardor of his love for the growing science. The powerful influence of Broca, especially visible at the beginning of its career, was not less real to the very close, in spite of the care which he took to avoid the appearance of personal control. Even when he abstained from taking part in any irritating debate, his attitude, the few words which might escape him, his vote, infallibly indicated to doubting minds, upon which side reason, moderation, and justice were to be found."

Upon the establishment of his Society, Broca began a craniological collection and, thanks to the surgeons of the navy, with whom he kept up an active correspondence, it soon attained respectable dimensions. Nevertheless, a

museum cannot be well maintained without a laboratory, and the difficulties in the way of obtaining the latter were very great, for the law forbade the taking subjects for dissection anywhere except to the rooms of the Faculty of Medicine. In 1867, however, Broca was nominated as one of the professors of the Faculty of Medicine and the difficulty was solved. He was entitled to a laboratory for his personal investigations, and two small rooms were assigned him for the purpose. It was here, with M. Hanry for his assistant, that he began his researches in the comparative anatomy of the primates. It was here, too, that he invented many ingenious instruments to be employed in craniometry, or the measurement of the skull. In connection with this especial work of Broca's, it may be well to give some explanation of what constitutes craniometry, without doubt, the most important part of our laboratory work. Craniometry comprises measurements of the dry skull, both its external and internal surfaces, its various angles, its relation to the spinal column, its internal capacity and the proportion and weight of the brain; external measurements are to be made, whenever possible, in the living person also. Moreover, these measurements, to be of value, must be made in large numbers, so that the average, or mean, may be trustworthy. To obtain these dimensions, many complicated and costly instruments have been invented, the greater number of those now in use having been devised by Broca. I had intended to bring some of these instruments here in order to give you an illustration of the manner in which they are used but I found that it would occupy more time than we can spare. I shall read you the names of Broca's craniometric inventions.

In 1860, he invented the *craniograph*: an instrument for giving the profile of the skull.

In 1864, the *new goniometer*. The instrument in use, for many years, for taking the facial angle was the one invented by Dr. Morton of Philadelphia; Jacquart made a vastly improved instrument, but Broca's goniometer had the merit of simplicity and cheapness.

In 1867, he produced the *stereograph*.

In 1869, the *cadre à maxima* and the *micrometric compass*.

In 1870, he invented the *occipital goniometer*, an instrument for ascertaining the angle of the back of the skull.

In 1873, he brought to perfection a surprising number of instruments mostly for the investigation of the *endocranium*, or interior of the skull. A perplexing obstacle in the pursuit of craniology was the difficulty, or rather, impossibility, of obtaining measurements of the interior without sawing open the cranium. This would spoil the specimen and could not, of course, be permitted. The instruments about to be mentioned were to be introduced through the occipital foramen, the large aperture in the base of the skull.

The *cranioscope* enabled a bright light to be thrown upon the interior of the skull by means of a mirror and lamp:

The *porte-empreinte intra-cranien*, or intra-cranial molder, is an instrument charged with a piece of wax by which a mold can be obtained of various portions of the interior.

The *endograph* is an ingenious contrivance for tracing on paper the curvatures and outlines of the endocranium for comparison with the external surface.

The *millimetric roulette* is a small wheel, graduated in millimetres, for measuring the curved outlines on tracings.

The *endometer* is an instrument for measuring internal diameters.

He invented, also, the *sphenoidal crochet* and *optic sound*; the *pachymeter*, an instrument for measuring the thickness of the skull at any point; the *turcica crochet*; the *acoustic sounds*; the *craniophore*; the *craniostat*; the *facial demi-goniometer*; the *auricular goniometer*; the *flexible bi-auricular square*; the *cyclometer*; the *facial median goniometer*; the *orthogon*; the *flexible goniometer*; the *goniometer of inclination*; and the *tropometer* for measuring the degree of torsion, or twisting, of the humerus, or arm bone, a racial characteristic of importance.

I fear this list of names has been rather tedious, but it is not only pertinent to the subject as illustrating Broca's mechanical ingenuity, but it may enable those present who

have no special acquaintance with craniology to form some conception of the immense and intricate labor involved in accurate measurements of the skull. Professor Huxley, speaking of these elaborate instruments, says, "One can not mention the name of Broca without the greatest gratitude."

This, then, was the beginning of the Laboratory of Anthropology. In 1868, the Minister of Public Instruction, M. Duruy, conceived the happy thought of establishing the practical school of high studies—*L'école pratique des hautes études*—by giving an annual allowance and an official character to the various laboratories connected with institutions of learning. Broca's laboratory was included. He at once instituted a system of teaching which attracted so large a class that he was obliged to ask the dean for permission to use a larger theatre.

The progress of the school was interrupted by the Franco-German war of 1870-1. Broca was, at that time, professor of clinical surgery at the hospital of La Pitié, which was from the very beginning of the siege of Paris crowded with wounded men. To these and to the care of the hospital he devoted himself exclusively, and his laboratory was forsaken. He had been one of the three directors appointed to take charge of the Public Assistance. During the days of the Commune, for which, as sterling republican and patriot, he had a supreme detestation, he remained at his post in Paris, taking care of the patients still in his hospital, but busying himself in taking plaster-casts of brains, thus beginning the superb collection of cerebral molds which is now to be seen in the Musée Broca. The President of the Council of Public Assistance fled to Versailles without notifying Broca, who was the vice-president, and leaving the money and securities in charge of the cashier. The danger of a seizure of these valuables by the communists was imminent, and Broca determined to save them, if possible. He, himself, carried them away, night after night, in carpet-bags, and concealed them at the hospital of La Charité, by the aid of the director. He was careful to leave three or

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four thousand francs in the safe, and, much to the disappointment of the insurgents, this was all that they found when, a day or two later, they made the anticipated raid. Apprehensive that the treasure might, in some way, be traced, Broca devised a bold scheme for its removal to Versailles. A wagon loaded with potatoes started for the hospital of Ivry with the precious carpet-bags concealed underneath them, and as soon as it had safely passed the outmost guard, the wagon was turned toward Versailles, which it reached in safety, and the bags were duly delivered to the over-prudent president. The amount thus saved to the government by Broca's firmness was seventy-five millions of francs, (\$15,000,000.) After the victory and the return to Paris, the directory of the Public Assistance was dissolved, and not even a vote of thanks was offered for this eminent service.

Broca was not the man to trouble himself about compliments. He had done his duty and now all his energies were devoted to bringing forward his beloved science. He founded the *Revue d'anthropologie*, the first number of which appeared in 1872, and this journal he continued to edit as long as he lived. His next undertaking was to establish a School of Anthropology, and so irresistible were the ardor and persuasion he brought to bear that in May, 1875, the Dean of the Faculty assigned him the second story over the Musée Dupuytren for the new school. For the purpose of furnishing and starting it, the sum of thirty-five thousand francs was subscribed by twenty-three members of the society. The work was commenced in July and completed in the following spring. The new school, however, was not to escape its share of opposition. The clerical party denounced the project without ceasing, branding its professors as atheists and materialists, and so thoroughly did they succeed in alarming the Minister of Public Instruction that that functionary was, with great difficulty, persuaded to authorize the school to proceed; when he, at last, did so, it was only for a year, and every difficulty and discouragement was thrown in the way.

Broca persevered through it all and, on the 15th December, 1876, the School of Anthropology was opened by him with a discourse entitled "The Programme of Anthropology," which has been translated into many languages. "It was," says Pozzi, "an eloquent plea *pro domo sua*," and certainly it was his own edifice, the school which he opened that day. Unlike most institutions in France, it had been established without the aid of the government, and by the personal efforts of the founder alone. Some time later, so brilliant was the success of the new school, the Municipal Council of Paris, and the Council-General of the Seine, spontaneously allotted it an annual subsidy of twelve thousand francs.

Still the ministry maintained its old position of distrust and almost hostility. Every year, it was necessary to apply for a new authorization which it required renewed efforts and influence to obtain. It was even then granted only for another year, and individually; that is to say, each professor was authorized, by name, to teach, but they were forbidden to call themselves a school, as indicating their solidarity. At length, the election of 1878 consolidated the republic and placed all institutions, contending for progress, in their rightful position. The School of Anthropology was duly and permanently authorized. Further, the Chambers voted it an annual subsidy of twenty thousand francs, which joined to its other resources, raised its annual income to thirty-four thousand francs, or nearly \$7,000.

The Society of Anthropology, the Laboratory and the School, all united in the same locality, formed, thus, a confederation known as the Anthropological Institute. The students from the school were admitted to the laboratory, where measurements and dissections were made under the direction of Paul Topinard, assistant director, and of Chodzinski and Kuhff, curators. In the neighborhood is the important library of the Society, and the finest anthropological museum in the world. Since the death of its founder, it has been appropriately named La Musée Broca.

It may be imagined with what satisfaction Broca witnessed the completion of his labors to establish his favorite

science on a permanent basis. Of his own work in Anthropology, it is impossible, in the limits of a lecture, to give any adequate account. His friend, Professor Pozzi, has attempted a bibliography of his writings which he admits to be imperfect, and which yet covers seventeen pages, in double columns of small type of the *Revue d'anthropologie*, which is a large octavo in size. I have been able to add some few articles to Pozzi's list, and, of the whole, have made the following enumeration:

Broca's contributions to the medical sciences, embracing anatomy and physiology, both normal and pathological, and surgery, number 243 articles and volumes. His papers on the anatomy and functions of the brain are 53 in number. His last and most important work on this subject, a treatise on the morphology of the brain, was left unfinished.

In anthropology, I find 109 articles and volumes upon comparative anatomy and general anthropology; 48 papers on general craniology, and 35 on special craniology; 27 papers on ethnology, and 19 on miscellaneous subjects. The total number of his printed articles and volumes, so far as ascertained, is 534. It is to be remembered that a large part of these papers are quite extensive, running through several numbers of the journals in which they appeared. Many of them were reprinted in pamphlet form, and he, himself, commenced a collection of his anthropological memoirs, of which three large volumes were published. Among the more important of these contributions may be mentioned his paper on Linguistics and Anthropology; his General Instructions for Observations on Anthropology. This last was a codification of the rules necessary to be observed by travelers and investigators: it was issued in 1865, and was completed ten years later by the Instructions in Craniology and Craniometry. This very valuable and original work had immense success, and was translated into nearly every modern language. Of his writings on the brain, the more important are his memoir upon cranio-cerebral topography; on the great limbic lobe; on the olfactory centres, and his admirable treatise on cer-

cebral nomenclature. One of his discoveries in this connection is associated permanently with his name. Certain patients who preserve the memory of words, have full use of the larynx, mouth and lips, have yet lost the power of articulation. The disease is called aphemia or aphasia. Broca observed that in the autopsies of these patients there was invariably present a diseased condition of a portion of the third frontal convolution of the brain on the left side. This convolution, thus inferred to be the seat of language, is known as "the convolution of Broca." In a vast number of cases, the prediction has been made, during life, that a certain portion of this convolution, the surface of its lower third, would be found diseased, and it has been fulfilled with mathematical precision. There are some exceptions in which the disease is found in the third convolution on the *right* side. Singularly enough, in most of these cases, it was found that the patients had been left-handed, and in these the right side of the brain is generally more developed than the left. The subject of the localization of the functions of the brain—by which we mean the discovering of the particular convolutions or other portions of the brain in which reside the functions of animal life—is of the highest interest; but is still to be considered as under investigation.

When, in 1872, it was determined to found a French Association for the Advancement of Science, after the model of the English Association, Broca took an active part in the organization. He was one of the provisional council of which Claude Bernard was the President. He established the section of anthropology, which has been brilliantly successful, the need of such a section not being denied in France as it had been in the English Association.

While all this work was being done in anthropology, it must be borne in mind that Broca was a professor of the Faculty of Medicine and a Surgeon of Hospitals, and that his duties in these connections required some hours of every day for their discharge. He was an incarnation of work. Naturally, the question arises, what was the quality of this amazing quantity of work performed, and would it have

been better for his fame if he had concentrated his energies upon fewer subjects? In some persons, production is a slow process, accompanied with extreme tension of the brain; the thought dwells a long time in the mind before it assumes the form in which it is to appear; such persons bring forth in sorrow and in pain. This was not Broca's case. To express his thoughts with extreme rapidity, whether by speech or pen, was, to him, the most facile of functions. It seemed play rather than work. And yet, Trélat, a critical judge, said of him, "Broca never wrote anything that came down to mediocrity." His mind was essentially many-sided, of restless activity and well sustained by the admirable physical organization which he possessed. His intense love of truth and the ardor of his convictions, at times, led him to too great vehemence of expression. He was impatient with those who did not see the truth as he saw it, or did not see it as rapidly as he did. His work in anatomy, physiology, and surgery stands, to this day, mostly unquestioned. His qualifications for anthropology are forcibly stated by one of his pupils, Professor Ball, who says: "Anthropology is a compound of so many other sciences that the intervention of a grasping and encyclopædic mind like Broca's is almost invaluable to form the connecting link between so many different branches of human knowledge. An excellent mathematician, a first-rate anatomist, a good Greek scholar, Broca combined in himself that diversified knowledge which the subject requires, with the synthetical tendencies which condense these disseminated forces, and make them converge upon a single point."

In person, Broca was of the middle height and strongly built. His broad forehead and lustrous brown eyes gave a very noble expression to his face. In private life, his relations were in every way admirable. Benevolent and generous, he was adored by his family, and those who were once his friends were his friends for life,—he "grappled them to his soul with hooks of steel." He was a delightful companion in his social hours. He had traveled much, and would relate his adventures and observations with great

humor. I may be allowed to quote one incident which he loved to recount.

While traveling in Spain he came to Seville and, desiring to be shaved, sent for the nearest barber. Figaro appeared and, knowing that his customer was a famous surgeon, refused to receive any recompense. "Sir," said he, with a lofty air, "that is never allowed between professional brethren!" The class of barber-surgeons exists to-day, in Spain, as it did when Cervantes wrote.

The crowning public honor of Broca's life remains to be told. In 1879, the Senate nominated him as permanent Senator, representing Science. He was proposed, of course, by the left. The right, or monarchical, side, made fierce opposition. He was an unyielding Republican, the founder of the Anthropological Institute, which meant free-thinking and atheism. They searched his writings for doctrines to convict him and, with great joy, published this quotation, "I would rather be an ape brought to perfection than a degenerate Adam." But this proved to have been a saying of Claparède's and not of Broca's. A sentence was taken from his Programme of Anthropology, "There is no faith, however respectable, no interest, however legitimate, which must not accommodate itself to the progress of human knowledge and bend before truth, if the truth be demonstrated." Even this scarcely orthodox doctrine, it seemed, was qualified by the preceding sentence which said that "science must keep aloof from anything not within its province."

Broca, with characteristic independence, took no part, whatever, in the proceedings, but he was elected. On the 19th February, 1880, a banquet was given him by some of his most attached friends, members of the Faculty of Medicine, of the Academy of Medicine, of the Society of Anthropology, of the Senate, of the Chamber of Deputies, &c., in commemoration of the high honor bestowed upon him. It was the grandest banquet ever given to a scientific man. The long table was filled with those who had shared his struggles and labors at different parts of his career from the

College of Sainte-Foix to the Senate. Professor Verneuil, his life-long friend, said to him, "If we are in great strength around thee, it is because thou hast continually made new friends, and hast never lost a single one."

In his speech of acknowledgment, Broca said, "they would not have thought of me if they had not known with what certainty they could count upon my devotion to republican principles; and if, among many others not less trustworthy and more skilled in political knowledge, they have chosen a man of science, it is because they hold science in high consideration, and believe that to serve science is to serve one's country best."

His speech was one of the most eloquent he had ever delivered, and ended with a sentence that proved strangely pathetic, in the light of the after occurrence. He said, "were I superstitious, I should believe, from the great happiness I experience to-day, that some great danger was threatening me."

Five months later, these now sorrowing friends followed him to the grave. On Tuesday, the 6th July, 1880, he was in his seat at the Senate and was attacked suddenly by faintness. The next day, he had apparently recovered, and Thursday evening was passed in work with his friend, pupil, colleague, and successor, Dr. Paul Topinard. Toward midnight, he was suddenly attacked with difficulty of breathing, he rose from his bed and, in ten minutes, he expired. The post mortem examination discovered no lesion of any organ,—no cause for this sudden taking-off. "Cerebral exhaustion" was the medical periphrasis, which implied two things;—that the man had worked himself to death and that how he died was a mystery. He died at the comparatively early age of 56, in the very plenitude of his powers and the height of his renown.

He was buried in the cemetery of the old church of the Celestins, in which his first labors in craniology had commenced thirty-three years before, and which led to his long course of studies in anthropology. The Vice-President of the Senate, M. Eugène Pelletan, in his oration at the grave,

said, after an eloquent eulogy upon the dead, "A new science, human palæontology, has just originated under our feet; at hundreds of ages of depth, our fore-fathers have been, in some way, surprised, lying pell-mell in the midst of the giant fauna of a vanished creation. Broca was one of the valiant pioneers who penetrated the foremost into the subterranean world of humanity, and who understood best how to throw light on such history as is left of it."

His work is continued by those who were his disciples and colleagues. Gavarret is the director of the School of Anthropology, Matthias Duval is director of the Laboratory, and Dr. Paul Topinard is the General Secretary of the Society and director of the *Revue d'anthropologie*.

The museum, now the *Musée Broca*, continues to increase its treasures: a recent number of the *Review* states that there are more than seven thousand specimens in craniology alone.

Broca left an enormous quantity of notes and drawings; also, two quarto volumes which contain the measurements of crania made by him during twenty years. These are divided into sixty-four series of different races, and record more than 185,000 measurements.

Madame Broca, his widow, has devoted a sum of money to found a "Broca prize"—*le prix Broca*. The subject of competition is "human and comparative anatomy in relation to anthropology." Writers of all nations may compete but their papers must be written in French. The prize is 1,500 francs, and it is to be bestowed every two years.

There is not much more that needs to be said of Broca and his work. If Europe be now garrisoned with societies of anthropology composed of earnest workers, loyally co-operating with the votaries of other sciences, and daily adding to the vast mass of facts and observations which have been accumulated concerning man, it is indisputable that it is to Broca we are indebted for their existence. Of his remarkable fitness for the task which it fell to him to undertake, there can be no doubt, but it was one predominating quality of his moral nature which gave him his

great influence over other men, and which has made his work so authoritative and enduring, and that was his unswerving love of truth. In science, he was always the judge—never the advocate. Pure and lofty-minded, he stood aloof from intrigues, and honors came to him unsought. The laureate's words may well be said of him,—

“Who never sold the truth to serve the hour.”

In conclusion, allow me to remind you that there is what may be termed a moral side of the science whose history we have been considering. To spend our hours in the study of man—to reflect upon his marvelous metamorphosis from the grimy savage of the cave to the gentleman of to-day—to ponder upon his curious devices, his laws, his marriage-customs, his battles, his religions, is to fill our minds with a belief in a common brotherhood more convincingly than peace societies or missionaries can teach, and to lead us to repeat with Terence:—“I am a man—therefore all human things concern me.”

¹ ** I desire to acknowledge my obligation to Prof. Pozzi's article in the *Revue d'anthropologie* for much of the details of the founding of the Institute.

NOTES.

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Report on the Huacals or ancient graveyards of Chiriqui. By J. K. Merrill. Svo., 1860, pp. 14.

(c) The Ethnological Society of London. (1844.)

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(f) The Anthropological Society of London. (1863.)

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(h) Sociedad de antropología de Madrid. (1865.)

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- (k) Berliner Gesellschaft für Anthropologie, Ethnologie und Urgeschichte. (1868.)

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- (l) Anthropologische Gesellschaft in Wien. (1870.)

Publications :—Mittheilungen der anthropologischen Gesellschaft in Wien. Wien, 8vo., vols. 1-12, 1871-82. Current.

- (m) Società italiana di antropologia e di etnologia. (1871.)

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- (n) The Anthropological Institute of New York. (1871.)

Publications :—The Journal of the Anthropological Institute of New York. 1871-2, 8vo., New York, Vol. I, No. 1.

- (o) Komisyja antropologii Akademii Umiejętności w Krakowie. (1877.)

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- (p) The Anthropological Society of Washington, D. C. (1879.)

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- (q) Deutsche Gesellschaft für Anthropologie, Ethnologie und Urgeschichte. (1870.)

Publications :—Correspondenzblatt der deutschen Gesellschaft, etc. Braunschweig, 4to, Vols. 1-12, 1871-82. Appears (with separate pagination) in the: Archiv. für Anthropologie; Zeitschrift für Naturgeschichte und Urgeschichte des Menschen. Braunschweig, 4to., Vols. 1-14. 1866-82.

. This society meets annually in some German city. The first meeting took place in Berlin in 1870.

- (r) Congrès international d'anthropologie et d'archéologie préhistorique. (1865.)

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9. Lisbon, 1880.

DEEP-SEA EXPLORATION.

Lecture delivered in the United States National Museum, April 22, 1882, by
Prof. WM. H. DALL.

LADIES AND GENTLEMEN:

The subject of this lecture may be defined as covering the investigation of all that relates to the ocean and its inhabitants, considered as a whole, with the exception of those features which are due to the influence of external causes, such as the tides, and those which are exhibited solely in shallow water, and therefore are in one sense characteristic rather of the coasts themselves than of the sea.

The field naturally divides itself into two areas of research, the physical and the biological. The physical features include the *temperature* of the sea-water in different geographical regions and at different depths: the *composition* of the water and investigations into the relative amounts of mineral salts, organic impurities, air, or other gases contained in it, and upon which its weight or density depends: the *motions* of the water contained in the bed of the ocean, which, apart from the tides, depend largely on its variations in temperature and density, and which, when tolerably constant and sufficiently well marked to attract the attention of navigators, are commonly known as ocean currents: and, lastly, of the *depth* of the sea or the topography and physical features of the bed in which it is contained.

The biological features include the capture and classification of the animals living in the sea, especially on its bottom, and the circumstances attending their existence there, both as regards their food and manner of living, and the results, if any, produced by the presence of their remains after death.

It is evident that the field is too large to be treated in detail within the limits of a single lecture, and therefore I shall confine myself to a general description of the means used in exploring the bed of the ocean, of the conclusions which appear to be warranted by the discoveries so far

made, and a brief review of the history of such explorations and the part taken in them by our own country.

The determination of the depth of the sea, at least to a certain distance from the surface, is a necessary preliminary to navigation, and hence has grown with commerce from the time when the primitive savage first launched his rude canoe in the Nile delta until the project of an Atlantic cable rendered it necessary to plumb the depths of ocean. The use of a weighted line for this purpose probably long antedates the historic period. The ordinary mariner's lead-line is familiar to nearly everybody, and consists simply of an elongated piece of lead with a slight indentation in its bottom, and a hole in its smaller end by which is attached a stout cord, large enough not to cut the hands when being hauled in, marked at regular intervals with tufts of red, white, and blue flannel, or small leather tags, to indicate the length of line run out. In the cavity in the bottom of the lead is usually placed a little tallow or hard soap, which will bring up a few particles serving to indicate the kind of mud, sand, or gravel, of which the bottom is composed. In ordinary depths the line runs out rapidly until the bottom is reached, and the thump of the lead on hard sand is distinguishable in still water at a depth of nearly a quarter of a mile.

But in greater depths and in waters, or from a vessel, more or less in motion, the accuracy of the soundings possible by the common method becomes rapidly less, and at depths of 1,000 fathoms (about a mile) the determination becomes quite untrustworthy.

This was not at first realized by investigators, and more or less confidence was placed in depths, such as those reported by Walsh, Denham, and Parker, who ran out from six to ten miles of line, in the Atlantic without recognizing that the bottom had been reached, in regions where we now know the depth does not vary much from two miles. The mystery and uncertainty which thus became associated with the conception of the depths of ocean had, as will be shown hereafter, an important effect in retarding attempts at exploration of the deep sea.

Scientific navigators, at an early period, began to attempt improvements in sounding apparatus for great depths. In this field the officers of our own navy have stood easily first, not only in order of priority of invention, but also in the perfection of the results attained up to the present time.

An early improvement was the substitution, in place of the ordinary lead-line, of a very fine line and a very heavy weight, which ran out rapidly, and was not intended to be recovered, but was cut at the surface. The change in the rate of running out of the line indicates when bottom is reached. I have thus sounded in depths of over a mile with satisfactory results. But the nature, as well as the distance, of the bottom, is an important feature in such investigations, and sounding instruments, which would pick up a good-sized sample of the bottom at the depth of a mile or more, and bring it safely to the surface, were the next in order of invention. Sir John Ross, as early as 1818, invented a "clanm" something like an old fashioned pair of sugar tongs, which should be closed by a falling weight on striking the bottom. The same idea, in different forms, has since been tried by several inventors, but it has never proved satisfactory in the long run. A piece of gravel or shell gets between the edges of the tongs, hold them apart, and the contents are washed out while hauling in. Sir John Ross, however, succeeded in several cases in bringing up several pounds of the bottom, once with some animals contained in it, from depths of over five hundred and possibly one thousand fathoms. Modifications of this principle are found in the so-called "Bulldog" and "Fitzgerald" sounding instruments, both of which have been well spoken of for their performances on certain occasions, but which have not borne the test of greater use.

The first important advance in this direction was made by Midshipman John M. Brooke, U. S. N., in 1854. It should be stated that in addition to the difficulty of getting the weight and line perpendicularly to the bottom, and knowing when the bottom has been reached, another important feature in sounding work is the recovery of the line and

lead. When sounding is done with hempen-line, and a sounding weight of fifty or one hundred pounds, it will be apparent that the friction of two or three miles of line, with its tags and instruments attached, must be enormous, even if it could be hauled up perpendicularly in still water. But when the vessel, as she always must, drifts a little, and the line comes up in a diagonal direction, the friction, added to the weight, renders the safe recovery of the line, sounding-cup, and thermometers or water bottles attached to it—a matter of great difficulty, some uncertainty, and several hours of time. In anything but the best of weather such work becomes almost impracticable.

Mr. Brooke's invention included an ingenious and simple apparatus for detaching the weight at the bottom of the sea, and leaving it there. Having thus to haul up only the line and the light tube containing the sample of the bottom, the labor was greatly diminished, and the time of hauling in much shortened. Brooke's apparatus has formed the basis of the only really successful sounding-cups which are now in use either by our own or foreign navigators. Improvements on the original form were successively made by Capt. Shortland, of the British navy, Capt. Belknap, of our own navy, and lastly by Lieut. Com. Sigsbee, U. S. N., while engaged in the service of the Coast Survey. The instrument, as perfected by Belknap and Sigsbee, does not seem capable of much further improvement, and works to a charm. The accessory machinery for use in deep-sea soundings, such as small engines, reels for the line, blocks, and elastic arrangements of rubber or steel springs to guard against the effect of sudden jerks upon the line, have been improved from time to time, and are fully described in publications on the subject by Sir Wyville Thomson and Lieut. Com. Sigsbee. The most important improvement of recent date is due to the distinguished Professor Sir William Thomson, of Glasgow, in 1872. This consists partly in the employment of fine steel piano-wire for the line instead of rope, and partly in the method of its use. Instead of the tags on the line to determine the length run out, the latter is known

by the number of revolutions made by the reel from which it uncoils, thus saving a vast amount of friction between the water and the wire-line. The moment of touching bottom is also much more clearly indicated by the light reel employed, which, assisted by the absence of friction on the wire, ceases to turn almost as soon as the weight touches bottom. It is impossible, in the brief account I can give you, to go into the minuter details which may be found in the publications previously mentioned.

This invention has proved to be of the greatest importance, and, singularly enough, though invented before the celebrated voyage of the *Challenger*, sent out by the British government, and immediately taken up by Belknap in our own sounding expeditions in the North Pacific, where its value was thoroughly demonstrated, the countrymen of the inventor continued throughout their three years' cruise to use the cumbersome hemp rope in all their sounding and dredging work, thereby diminishing the effectiveness of their operations by at least sixty per cent.

Partly from the fact that the expense of deep-sea sounding expeditions is so great as to place them beyond the means of private individuals or scientific societies, and partly from the unsatisfactory results and enormous depths reported by naval officers of several countries, governments and scientific bodies remained, until recent years, indifferent or sceptical as to the practicability of making researches in the deep-sea which should produce results at all adequate to the expense involved.

It was only when the subject of telegraphic communication by cable under the sea assumed a commercial importance which could no longer be ignored, that a knowledge of the conditions of the sea bottom, especially in the North Atlantic, became a necessity. Deep-sea exploration may therefore be said to have commenced systematically only about 1856. The survey of the "telegraphic plateau" began about this time by the aid of the British and American navy, and even with the comparatively imperfect means then available, a very large amount of information was gathered in the course of the succeeding four or five years.

I have already spoken of the attempts at securing specimens of the bottom which accompanied sounding by various methods. It is evident that the amount of material which can be obtained by even the best modern sounding apparatus is too small to give any adequate idea of plants or animals which might exist on the sea bottom. This follows both because only the smallest animals could find entrance into the tubes intended to bring up specimens of bottom, and also because the apparatus is not fitted nor intended for the purpose of capturing living animals, and if any existed on the spot struck by the lead the blow would probably reduce them to fragments.

Other means are then necessary for this purpose, and since deep-sea explorations have lately included both dredging and sounding as well as temperature observations and collection of water-samples, I shall proceed to describe the various instruments used for these purposes before considering the work accomplished by them.

The dredge and trawl are instruments which have been used from time immemorial by fishermen, and which, in a modified form, are employed in the deep sea for the capture of its inhabitants. The naturalist's dredge was designed in nearly its present form by O. F. Müller, of Denmark, a very distinguished early naturalist, more than a century ago. It has been made more convenient and effective, but the modifications are very slight. The best form seems to be that adopted thirty years ago by Dr. Stimpson, and used by American naturalists ever since. It comprises a frame of heavy iron forming a parallelogram, the two long sides beveled outward to act as scrapers; it is perforated along the hinder edge with a row of small holes, into which a net and two flaps of canvas are laced with copper wire. The canvas is outside of the net and longer than the latter, and protects it from being cut by sharp stones on the bottom as it drags half full of mud behind the frame. Two movable arms project forward from holes in the short sides of the iron frame, coming together about two feet in front of it, to one of which the dredge-rope is attached; but the other is

only lashed to the first with pack thread. Thus, in dragging over the bottom, if the dredge catches on an immovable rock, the strain breaks the pack thread, the two arms straighten out, and the dredge can usually be pulled away from the rock without loss of frame or rope.

The trawl, as used by the English expeditions, is almost precisely the same as the ordinary fisherman's beam-trawl, in which the material is collected from the bottom by the weighted edge of a net which drags behind an iron bar or beam which goes upon two runners of flat iron. For deep-sea work, however, American investigators, especially Sigbee, Prof. Alexander Agassiz, and Prof. Verrill, have introduced important modifications, not only of the trawl, but of the dredge, rakes, and scrapers for the bottom, and various seines and other apparatus for cleansing and assorting the material collected.

A very important addition to the means of collecting in deep water was invented by Captain Calver, R. N., during the voyage of the *Porcupine*. This consisted in employing "swabs" or "tangles," large mops of shredded rope-yarns, to sweep the bottom with, attached to the dredge to an iron bar or to a weight. Many of the deep-sea animals, such as crustacea, sponges, starfish, and sea urchins, are rough or prickly, and the long mops of wet threads entangled them by hundreds, and came up covered with organisms when the dredge had nothing but mud and a few small creatures in it. A very large proportion of the animals collected from the sea bottom has been obtained by the use of these tangles or swabs, though many of the animals come up in a mashed or broken state.

To obtain samples of water from any depth, without admixture of other water, brass cylinders with poppet valves at top and bottom have been used. These are very heavy, and, as they descend, the pressure of the water raises the valves and the water passes steadily through until the required depth is reached. Then the line is hauled in, relieving the upward pressure on the valves, which fall and the enclosed water is thus kept intact for analysis.

Several devices more complicated than the ordinary "water bottle" have been employed for the same purpose with success, especially one invented by Captain Wille, of the Norwegian navy, and the Sigsbee water-cup, but all embody essentially the same principle.

Most of you have seen thermometers which register the greatest rise or fall of the fluid in their tubes by means of a little enclosed index like a double-headed pin, and which are known as self-registering. Such an apparatus is evidently necessary to obtain a knowledge of the temperatures of the deep sea, since no one can read the thermometers when submerged, and the height of the column when hauled in will necessarily represent only the latest temperature near the surface.

All attempts to use ordinary self-registering thermometers in deep-sea work failed as soon as tried; not only because the immense pressure of the sea water at great depths compressed the bulb of the thermometer, thus forcing the fluid in the tube to a point far above that which would register the actual temperature, but because the pressure was usually sufficient to crush the bulb and tube into fragments at a comparatively moderate depth. At 2,500 fathoms, which is the average depth of the ocean, the pressure is over three tons to the square inch, which is far beyond the endurance of any ordinary thermometer bulb. To overcome this difficulty, sometimes the entire thermometer and sometimes the bulb of the thermometer has been surrounded by a second bulb nearly filled with alcohol, so that the outer bulb was supported by the fluid and the air bubble by yielding to compression would relieve the interior bulb from its evil effects. This method has proved completely successful and the thermometers now in use for deep-sea work are entirely of this description. Those with an exposed stem and double bulb are preferred as responding more readily to the temperature, though subject to a slight correction for pressure from which the totally enclosed instrument is free.

Sir John Ross, on his remarkable voyage in 1818, was supplied with thermometers of this sort, and took the first

deep-sea temperatures. But the instrument seems to have been forgotten even in England, for, in the subsequent voyages of Beechey (1825) and Lütke, (1826) only common thermometers were supplied, and the device seems to have been independently re-invented by Glaisher, Negretti, and Miller, within the last twenty years. As the thermometers most commonly used for this purpose are made by the firm of Casella, in London, they are usually called Casella thermometers; Negretti and Zambra, of London, have invented another form of thermometer less convenient in size and shape than the Casella, but which offers a meritorious advance in some other directions.

Metallic thermometers, registering temperatures by the unequal contraction and expansion of different metals combined in one instrument, have been invented, and, while perfect in theory, have not been found satisfactory, except in moderate depths, when put to actual test.

Having described the various instruments employed, it remains to indicate briefly the manner in which they are used, premising that, for the minute details of operations of some complexity, it will be necessary for those interested to refer to special treatises on the subject.

For good work in great depths of water a steam vessel is absolutely necessary. It is important that the lead line, whether of rope or not, should descend perpendicularly, as otherwise the length of line run out does not indicate the true depth of the water, and greater strain on the line is involved in hauling in. Now at sea there is always some wave motion or swell, even in the calmest weather, and unless the vessel can be kept in her original position by a gentle use of the propelling machinery she will certainly drift away from the spot at which the lead was dropped into the water. In running lines of soundings the use of steam is also necessary to continue on the desired course irrespective of the winds. The distance between any two stations, not fixed by astronomical observation or bearings on land, can also be determined more accurately in the case of a vessel under steam. A steam-engine is also required to haul

in the line, which in dredging would otherwise require the labor of many seamen.

The operation of sounding is sufficiently simple, and requires no explanation. A thermometer is usually attached to the line at a short distance above the lead or sounding cup. If serial temperatures are desired several thermometers may be attached to different parts of the line, or several water bottles if water samples are required.

In dredging or trawling the dredge or trawl is lowered to the bottom by a line of sufficient strength. This, in the work of the Coast Survey, is of wire rope, as suggested by Prof. Alex. Agassiz, which, as compared with the rope used on the Challenger expedition, saves much friction, much room in stowing on the vessel, and easier handling, with no loss of strength, and a great gain in the time occupied in reaching the bottom and hauling in. In order that the motion of the vessel in drawing the dredge over the bottom may not tend to raise its mouth off the bottom, a weight is usually attached to the line at some distance in advance of the dredge and some slack line is run out, the resulting position of the ship, weight, and dredge being shown on the diagram exhibited.

On the 1st of September, 1818, Sir John Ross, R. N., ran out 1,000 fathoms of line, and in the mud, brought up by the sounding-cup, were tubicolous worms, while at 800 fathoms was entangled a fine brittle star-fish, sometimes known as a "Medusa's Head" on account of its many arms. This shows that the actual depth could not have exceeded 800 fathoms (since star-fish do not swim,) and was probably less, but it is the first recorded instance of the capture of animals from any such depth.

In 1847, Sir James Clarke Ross, R. N., published an account of his antarctic voyage, in which he states that several shell-fish were brought up from 1,000 fathoms on that expedition, and that he believes the bed of the ocean to be teeming with animal life.

In spite of such testimony the existence of life on the sea bottom, at a depth beyond two or three hundred fathoms,

was generally doubted or denied up to a comparatively recent time.

Between 1840 and 1850, Prof. Edward Forbes, of Britain, prosecuted extensive researches into the fauna of the ocean around Great Britain, and also in the *Ægean* sea during the Mediterranean survey. Assisted by Jeffreys, MacAndrew, Ball, and others, dredging in moderate depths was energetically prosecuted and facts gathered together. Forbes was the first to philosophically treat these questions, and was a true pioneer in this work. But some peculiarities of the particular part of the Mediterranean, in which his researches were conducted, led him to the belief, true only for that locality, that animal life dies out in the region between two hundred and three hundred fathoms in depth, and that a zero of life is reached about the latter point.

The premature death of Forbes brought to an untimely end those studies which would have doubtless modified his views, while the weight of his opinion, and the peculiar charm of his personality lingered after him with such effect as to render naturalists, in general, incredulous or indifferent to evidence which gradually accumulated to show that he was in error.

In 1846, Admiral Spratt, R. N., dredged in 310 fathoms several shell-fish, in the vicinity of Malta.

In 1850, the veteran professor Michael Sars enumerated nineteen kinds of animals, obtained by him off the coast of Norway, in more than 300 fathoms.

In 1860, Dr. G. C. Wallich, naturalist to a British sounding expedition in the North Atlantic, in H. M. S. *Bulldog*, commanded by Captain Sir Leopold McClintock, obtained a number of star-fishes which had attached themselves to a sounding-line which had rested on the bottom at a depth of 1,260 fathoms. On his return Dr. Wallich published the first part of a work on "The Atlantic Sea-bed," in which he warmly advocated the view of the existence of life at great depths. About the same time a broken cable was taken up from a depth of 1,200 fathoms, in the Mediterranean, upon which a small true coral had grown since the cable was laid.

This was discussed by Milne-Edwards, the distinguished French naturalist. Meanwhile the energetic Scandinavian naturalists were pushing their researches into the deeper water along the Norwegian coast.

Still these facts failed to secure that general consideration which was necessary, in order that they should have their appropriate effect on scientific opinion. Individual naturalists, it is true, were more or less impressed; the views of Forbes were occasionally called in question, but it was reserved for American naturalists and hydrographers to initiate that series of researches which has revolutionized scientific opinion, remodelled our views of the physical conditions of the deep sea, and culminated in the most remarkable and fruitful scientific expeditions of any age.

In May, 1867, under instructions from the Superintendent of the Coast Survey, Assistants Henry Mitchell and L. F. de Pourtalès explored the narrow part of the Gulf stream between the northwest end of Cuba and the American coast. Dredgings were undertaken in depths extending nearly to five hundred fathoms, and representatives of all branches of the animal kingdom below the fishes were brought up. The work was interrupted by an outbreak of yellow-fever on board, but the main facts were sufficiently verified, and their important bearings fully set forth in the report of Pourtalès. The depths from which these animals were obtained were not greater than those from which Sars had obtained living organisms on the Norwegian coast, but those collected by Sars were mostly animals common to the adjacent shore, or which might be expected to be found in shallow water by fuller search. But the Gulf-stream dredgings revealed an entirely new and beautiful series of forms, many of them like nothing which had previously been known to naturalists—corals, sponges, crinoids, starfish, echini, shells, worms, crustaceans—all offered new and elegant representatives which attracted the attention of specialists in every branch of marine zoölogy. In the following year six lines of dredgings were run by the Coast Survey observers across the Gulf stream, from the Florida reefs to the deep sea be-

yond the stream. Nearly one hundred hauls of the dredge were made in all, and organisms were brought up by the bushel, especially from a region averaging somewhat less than three hundred fathoms, but also to some extent from the deeper waters.

The work of 1867, however unimportant in the actual bulk of the collections made and the depth reached, when compared with more recent investigations of the same kind, was really the initiation of a new era in research. When we look back at the history of deep-sea exploration we see that this need not have been so, perhaps we may say ought not to have been so, but as a plain matter of fact it was so, in spite of the absence of any emphasis upon it in foreign accounts of the progress of such investigations.

In 1868, fresh publications were made by Sars, father and son, whose researches on the Norwegian coasts have been alluded to. On the coast of Portugal, Bocage and Perceval Wright dredged in nearly five hundred fathoms from an open boat, obtaining the remarkable "glass sponge," *Hyalonema*. Wyville Thomson and Carpenter in the *Lightning* explored the sea-bed south of the Faroe Isles, and reached a depth of 550 fathoms. In 1869, the intense interest excited by these discoveries led to the voyages of the British naval vessel *Porcupine*, with Dr. J. Gwyn Jeffreys, Professor Wyville Thomson, and Dr. W. B. Carpenter, in charge of the scientific operations, and dredgings were made in 2,435 fathoms, or nearly three miles, reaching nearly the deepest part of the North Atlantic. Smitt and Ijungmans, in the Swedish frigate *Josephine*, dredged from the coast of Portugal to the Azores, and then across the Atlantic to America. The third cruise of the U. S. Coast Survey steamer *Bibb*, Robert Platt, U. S. N. commanding, was made, with Pourtales in charge of the dredging operations. He was later in the season joined by Prof. Louis Agassiz, whose report on the work to the Superintendent of the Survey states that "we owe to the Coast Survey the first broad and comprehensive basis for an exploration of the sea bottom on a large scale, opening a new era in zoölogical and geological

research." In 1870, the Porcupine was again sent out by the British Government, and, under the supervision of Jeffreys and Carpenter, work was done between Britain and Gibraltar, and thence into the Mediterranean.

In 1871 the Coast Survey launched a new steamer, the Blake, especially adapted for hydrographic work in the deep sea, which, under the command of Lieut. Commander Howell, at once began work in the Gulf of Mexico. Another steamer, the Hassler, for work on the Pacific coast, was prepared, and sailed for California *via* Cape Horn with Prof. Agassiz, Pourtalès, Dr. Thos. Hill, Dr. Franz Steindachner, and others, as a scientific corps. Much natural history work was done, but deep-sea work was rendered impracticable by unforeseen circumstances after the voyage began. In 1872 the voyage of the Challenger, now of world-wide celebrity, was begun under the scientific supervision of Sir Wyville Thomson and the naval superintendence of Capt. Sir G. Nares, R. N. This voyage extended to both oceans; soundings were made to 4,475 fathoms, dredgings to 3,875 fathoms, and the trawl was used in over 3,000 fathoms. This expedition occupied three years and five months, and the scientific results are being published by the British Government in a magnificent series of quarto volumes. During the year 1872 the Coast Survey continued its systematic development of the hydrography of the Gulf of Mexico and the adjacent sea, the dredgings being taken under the supervision of Dr. W. Stimpson. They formed the last scientific work of that lamented naturalist, whose dredgings and investigation of the marine fauna of the Eastern United States had extended over twenty years.

The deep water work of the United States Fish Commission, organized during the preceding year, began this season, and has steadily grown in importance and extent from year to year, under the direction of Prof. S. F. Baird and the immediate supervision of Prof. A. E. Verrill.

In 1873 Capt. Geo. E. Belknap, U. S. N., undertook his now celebrated sounding cruise across the North Pacific, in the U. S. S. Tuscarora. No dredging was done, though sev-

eral animals were brought up by the sounding-cup, but the expedition is memorable as having been the occasion of the first practical use of wire in sounding, for the important improvements introduced by the commander into sounding instruments and methods, and for the great depths obtained in the northwestern part of the Pacific, being 4,655 fathoms, the greatest depth ever measured by reliable means, and one which is probably little, if at all, exceeded in any part of the ocean. This cruise terminated in August, 1874. Since then expeditions have multiplied, and to enumerate them with the space at my command would be hardly more interesting than the incorporation of a statistical table into this already, (in spite of its title,) I fear, rather dry discourse. I cannot avoid, however, a reference to the hydrographic work of the *Bache* under Sigsbee and Bartlett, in the Gulf and Caribbean sea, in 1874-1879. Not only was a greater area of deep water more thoroughly worked out by these officers than has yet been equally explored in any other part of the globe, but the improvements in sounding and dredging apparatus made during the progress of the work have almost revolutionized such investigations. These have been in part alluded to already. During parts of 1877, 1878, and 1879, Professor Alex. Agassiz made one of the party, with supervision over the dredging work. To him is due, among many other details, the substitution of wire-cable for hemp-line in dredging, which bore especially important fruit; and by him the most important scientific results of these cruises were announced to naturalists.

The historic part of this lecture must close with a mere reference to the valuable work of the Norwegians, Sars, Friele, Danielssen, etc., in the North Atlantic, on the steamer *Vöringen*, (1876-8;) of Jeffreys, in *H. M. S. Valorous*, (1875;) Murray, in *H. M. S. Knight Errant*, (1880;) and the French expedition of 1881, on the *Travailleur*.

This model of the Gulf of Mexico, from the work of the Coast-Survey hydrographers, illustrates the topography of that part of the sea bottom. You will observe the singular plateau which extends about the peninsula of Yucatan and

west from Florida. Formerly it was supposed that the peninsula of Florida was due to alluvium from the rivers of the Mississippi valley and other sources settling against a barrier of coral reefs which grew toward the south and west, as their northern portions were smothered by sediment. This shows, however, that the coral reefs have simply availed themselves of the advantages presented by the steep edge of the above-mentioned plateau so abundantly supplied with food for them by ocean currents; and that, in its main features, Florida was outlined by different and far older agencies than the now existing coral reefs. The same is evidently true of Yucatan.

To another point I would call your attention as of economic interest. We know that by most engineers it is believed that experience has proved that channel-making by the jetty process is a mere temporary alleviation of bars and other obstructions to commerce. The permanent success of the Eads' jetties is even now a matter of doubt, and there is no doubt that in time extensions will be called for. But it will be observed that at no other point on the Gulf coast of the United States is the 100 fathom line so near the actual coast as here, and the inference is, perhaps, not too far fetched that, therefore, not only is it probable that with certain extensions of the jetties (other circumstances permitting) a point will eventually be reached where the slope seaward is so steep that a bar can hardly form or be maintained, but also that at no other point on the whole Gulf coast could the jetty system have been applied to the improvement of a river mouth with any reasonable prospect of maintaining a permanent channel.

It may also be observed, from an examination of this model, what we should find confirmed by an equally thorough survey of the ocean at large, (as we know from recent examinations of the Atlantic sea-bed,) namely, that while the sea-bed, like the dry land, has its irregularities, they differ in character from the irregularities of the dry land. It is true that sharp peaks and elevated rocky areas have been discovered in both the Atlantic and Pacific, though none

appear in the Gulf of Mexico. But, exclusive of these, which probably project from a comparatively even slope, the topography of the sea-bed in deep water is carved in broad and easy curves, which find no parallel on land. This results from the absence of denudation in the sea. On the land, torrents, storms, rivers, winds, all modify the surface, which must have originally been much like that of the sea-bed. Gullies, ravines, terraces, sharp-weathered rock faces, peaks, and pinnacles, are formed in air by the denuding agencies. In the deep sea there can be no sharply limited currents or denuding agencies. Such currents as may exist will have ill-defined margins, will move at slow rates, and cannot be conceived of as plunging sharp grooves or gullies in the floor of ocean. It is probable that the very deep sea is for the most part a region of profound quiet, where the waters are and remain unmoved, either by the comparatively superficial ocean currents and tides, or the pulses of the waves as they beat on distant shores. The great deeps which you see represented on this model and in the chart of the Atlantic sea-bed here exhibited are not paralleled by anything on dry land, except the basins of the Great Lakes. Were they above the sea they would become lakes at once, and would gradually be filled by sediments. Their existence here in the deep sea disposes of the hypothesis rashly advanced by some glacialists, that great lake basins are due only to the action of glaciers; and that without the previous existence of land-ice there would be no large lakes on the earth's surface. It would be a bold man who would propose to locate glaciers on the bottom of the Gulf of Mexico.

The circulation of the waters in the sea has been theoretically accounted for by differences of density due to evaporation and consequent over-saltiness, and to differences of temperature between the water at the poles and at the equator. This theoretical circulation doubtless exists in a more or less modified form, and affects the actual motion of the waters. But the existing oceanic circulation in its greatest part is due directly to the influence of the trade-winds, and is, comparatively speaking, superficial.

We know that the deep sea is very cold. Cold water sinks, and a submarine polar indraught of cold water must replace the constant streams of tropical surface water which flow away from the equator, in order that an equilibrium may be maintained. The warmest water that has been found in the deep-sea (over 100 fathoms) is at 50° . 5 F. in 2,550 fathoms; the ordinary temperature is but little above the freezing point. This, however, does not affect the life of organisms existing there, which are all cold blooded, many of them coming into shallow water in the Arctic regions.

That many problems in regard to the deep-sea are still unsolved, goes without saying. Time does not permit me to discuss them here. In conclusion, I will briefly sketch the conditions of life at the bottom of the deep-sea.

In the first place, fishes and organisms of almost every marine group lower in the scale than fishes, are to be found in the deeps. In order that these animals may exist where the pressure of the water may be several tons to the square inch, it is indispensable that their fleshy tissues shall be so loosely constituted that the water shall be able to permeate them thoroughly, and thus itself equalize the external pressure. Hence, the fishes and other large animals inhabiting the abysses are, so far as their flesh is concerned, of an almost gelatinous consistency. While they might probably survive a very gradual change of pressure and be able to live in shallow water, yet when they are rapidly brought up from the depths in a dredge, they are invariably dead, their internal organs usually turned inside out, their eyes starting from their heads, and their forms more or less altered from the sudden decrease of pressure and expansion of the tissues.

Other inhabitants of the sea-bed have rigid exoskeletons or shells, but the soft parts are always permeable.

While most of the deep-sea animals are small, fishes, certain spider-like crustacea and some echinoderms attain a considerable size.

As the depths must be almost entirely dark unless lighted

by phosphorescent animals, we might expect to find these creatures blanched or generally white. This is true of many of them, but others of all groups, are more or less brilliantly colored. From disuse in some forms, the eyes have become abortive or entirely lost; others have very large and delicate eyes, suitable for seeing by a very small amount of light; yet still others have eyes of about the character normal in the groups to which they belong. The extreme quiet and uniformity of the environment at the sea-bed is favorable to the development of delicate markings, and details of sculpture in the hard parts of shells, etc., and the abyssal animals are notable for their extreme grace and beauty in this particular, and singularly enough, also in many species for the remarkable elegance of their pearly lustre. With no struggle for existence, a wonderful range of variation develops, unchecked by natural selection, and it is hard to say in certain groups what is a species.

Sea-weeds do not grow at great depths, hence these animals are all carnivorous. At first sight it would seem as if they would destroy one another, but it must be remembered that even in the open ocean there is a constant rain of animal and vegetable matter slowly falling from the surface toward the bottom. Mr. Moseley judges from experiment that small marine animals (*salpa*) fall at the rate of about a mile in two days, while the saltiness of the water prevents rapid decay. I have found grass roots, land and fresh water shells in dredgings from 800 fathoms. It is still a matter of some doubt whether certain little shells belonging to the *Foraminifera* and found in incalculable numbers on the sea-bed (which in many cases is made up of their remains) actually ever live at the bottom, or whether they, too, are derived from the vicinity of the surface and sink only when dead or dying.

But I have already trespassed too long on your good nature, and will conclude this discourse by referring those who would pursue the subject further to the authorities previously mentioned, from whom I have derived much as-

sistance in the preparation of this lecture, and to whom the exploration of the sea-bed is chiefly due.*

* Depths of the Sea: C. Wyville Thomson; New York and London, Macmillan & Co., 1873.

Deep-Sea Exploration: a Lecture by J. Gwyn Jeffreys; London, 8vo., Van Voorst, 1881.

Deep-Sea Sounding and Dredging: C. D. Sigsbee, Lieut. Com. U. S. N., Asst. U. S. Coast Survey; Washington, Gov't Printing Office, 1880.

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Reports of Jeffreys, Carpenter, Thomson and others in the Proceedings of the Royal Society, 1868-1880.

The Norwegian North Atlantic Expedition—Zoology, (etc.) Collett, Koren and Danielssen, &c., Christiania, folio, 1880-81.

Thalassa, an Essay on the Depth Temperature and Currents of the Ocean, by John James Wild; London, Marcus Ward & Co., 1877.

HOW WE SEE.

Lecture delivered in the United States National Museum, April 29, 1882. by
DR. SWAN M. BURNETT.

LADIES AND GENTLEMEN:

When man first found himself capable of forming a proper judgment of the workings of Nature, the sense of vision must have excited in his mind an emotion of the greatest wonder. That he was cognizant of objects situated at distances very remote and beyond the reach of his touch, and through a medium the very existence of which was a mystery above his comprehension, must have seemed to him a problem which defied even an attempt at solution. We are not aware that any effort has been made by savage or barbarous tribes to account for any of the phenomena of sight. They give ready explanations of the cause of thunder and lightning, of the origin of men and animals, the creation of fire and other natural phenomena, but the sense of sight is so wholly unlike anything else with which they are familiar that they have no analogies to fall back on, and must accept it as a primary gift of the Divine Spirit. It is only when the intellect has developed to such a degree as to enable it to consider things as related to each other, and analyse phenomena as they present themselves to the mind, reducing them as far as possible to their constituent elements, that the sense of vision is considered a subject within the scope of human investigation. The physiology of vision, therefore, belongs preëminently to the scientific era in the history of intellectual development. It finds no place, so far as I know, in the era of superstition. To tell you what the scientific method of thought has accomplished in this field is the object of the remarks we shall make this afternoon.

In the study of the phenomena presented by the sense of vision we find four separate links in a chain of sequences. If any one of these links is missing there can be no sensation of sight.

The first link in the chain, naturally, is the object to be seen; the second, the medium connecting this object with

the eye; the third, the eye itself; and the fourth, the nervous center which converts the impression made on the eye into a sensation.

Of the object to be seen, but little need be said. All that is necessary being that it be found in the medium which brings it in relation with the eye, that is to say, it must be placed in what we call the light. As you well know, no object situated in what we call darkness can be seen. The object may be luminous within itself, that is, it may generate the light which it gives off, as in the case of the sun, candle, lamp, fire, &c.; or it may merely reflect or throw off the light which comes from some other source, as in the case with the large majority of objects by which we are surrounded; but it is absolutely necessary for the purposes of vision that light proceed from it.

This light is the second link in our chain, and it is one of the most wonderful and mysterious of the workings of Nature. What is light? Is it a something, or only an essence or a spirit? What are the laws governing its action? These are questions which the earlier philosophers asked themselves and sought, for a long time in vain, to answer.

We will not occupy your attention with any of the theories before the time of Newton, as it was his genius which first placed the study of the operations of light on a solid basis.

His theory was that all luminous bodies gave off minute impalpable corpuscles which passed directly into the eye and affected the retina and optic nerve. This hypothesis was, of course, not susceptible of demonstration, but he succeeded by it in accounting for many of the manifestations of light in a manner more satisfactory than had been done by any other theory then known. The corpuscular or "emission" theory, having the weight of the great name of Newton attached to it, was accepted by most philosophers of his time, and, with the additional weight of tradition, affected many who came after him. All theories respecting the ultimate facts of any phenomenon in nature must be based largely on *à priori* reasoning, for no ultimate knowl-

edge is provable. Our facts reach back only to a certain point—never to the beginning. Science is constantly pushing back her line of primordial data, but it is hardly probable that the time will ever come when the essence, so to speak, of any manifestation in nature can be demonstrated. Nature's laws, we can study and unravel—the origin of these laws will probably ever remain an unsolved mystery. The nature of light is one of these mysteries which can be approached by speculation alone, and as none of the postulates need be demonstrated, the field for the exercise of the speculative faculty is practically unlimited. Newton adopted his corpuscular theory, not because he could demonstrate the existence of the corpuscles, but because by so doing he thought he was explaining the phenomena with the least violence to known laws and the scientific principles of the time.

There was one great original mind, however, which came after him, that refused to accept any theory on any other man's authority, however great that man might be. This was Thomas Young, probably the most universal genius England has given to the world. Thomas Young did not consider the corpuscular theory of light satisfactory, and proceeded to revive and modify what is called the undulatory theory, which had been broached by Huygens before the time of Newton. By this theory he was enabled to account in a more consistent and satisfactory manner for some of the manifestations of light than could be done by the corpuscular theory of Newton. This undulatory hypothesis as promulgated by Young, is the basis of all modern speculations as to the nature and laws of light. In common with all theories dealing with the essential nature of things, it draws largely upon our credulity, and asks us to accept as data as many postulates which have never been and which can, from the very nature of the case, never be proven as does the corpuscular theory of Newton.

In the first place, we are required to suppose the existence of an ether which is coextensive with the universe. It fills the interstellar space to the farthest fixed star, whose distance

is incalculable, and insinuates itself into the infinitesimally minute interstices of the hardest known substances. It exists alike in a vacuum and in the substance of the diamond. It is of such extreme tenuity, that a mass of it as large as the earth weighs only a few grains. It is the least material of all substances, and yet it possesses a tension or elasticity far in excess of any matter of which we have any knowledge.

This is the medium through which that form of force we call light is supposed to act. It has, as you see, no existence whatever as a fact capable of demonstration by any of the ordinary methods of proof. It exists alone in that highest faculty of the mind which, by its creative power, sets man above the beasts of the field—the imagination.

But our task does not end here. We have the medium, but we have not the manner in which this is acted on to produce the effect we know as light. Again the imagination must be brought into action. The mind which first conceived of light as being a force, the result of wave motion, gave us the key which has unlocked some of the deepest mysteries of Nature, and made modern physical science and all that belongs to it, and has resulted from it possible; for the foundation of the physical science of the present day is the fact that all energy is but a mode of motion. I think it can be broadly stated that all forms of energy, whether in the organic or inorganic world, are but modes of motion. The ancient philosopher, when asked to define Life, moved his arms, drew the air into his lungs, and expelled it, and said, "This is life," meaning that all we knew of life were its phenomena. But he explained better than he was aware of. He expressed thus the idea which underlies the modern concepts of Nature and her laws, that life is motion. Without energy, as expressed by some form of movement, there can be no life; and life is but one form of energy, one particular kind of force. All other forces in Nature are likewise but representations of some kind of motion—they are not Things. The whole of the teaching of modern science tends to the demonstration of the fact that there are but two Things in nature—matter and its motion.

Applying this principle to the ether, Young supposed that the light force was due to an undulatory motion set up in it by the vibrations of the molecules of luminous bodies. It is now a pretty well demonstrated fact that when bodies get into the condition known as "hot," a change takes place in the ultimate particles of the matter composing them. They are set in vibration. The more heated they become the more extensive will these molecular vibrations be; and as the space occupied by the molecules in a state of vibration is greater than when they are at rest, the substance when heated is larger than when cool. The motion of these ultimate molecules is communicated to the ether by which they are surrounded, and it is set in undulatory motion, just as waves are produced on the surface of water when a body is let fall upon it, which disturbs the relation of its molecules. As the motion of the molecules of the heated body is regular, the wave motion communicated to the surrounding ether will also be regular, that is, the waves will follow each other at regular intervals of time.

Up to this point everything must be taken for granted, for, as I have said, not one of the accepted facts is capable of experimental demonstration. Accepting this much, however, we can deduce certain laws which are capable of substantiation by experiment, and by them we are able to explain all or nearly all the phenomena of light and vision. Though we have shown you that light is only a form of force—a mode of motion—it will be more convenient to speak of it as a Thing, without reference to the ether or wave motion. Thus, when we say that light travels at the rate of 186,000 miles per second, we mean that the motion communicated by the luminous body to the ether is felt 186,000 miles away at the end of a second of time. There are a few fixed laws governing the action of light, to which we briefly call your attention, because on them depends all our knowledge of the physiology of vision.

In the first place, we know that light moves in straight lines, and never turns out of its course unless it meets with some substance having the property of deflecting it. There

are two forms of deflection. In one the light is thrown back by the surface of the interposing body in the direction from which it came; that is to say, it is reflected. In the other it passes through the body, but its course after its passage is not the same as before; in which case it is said to be refracted. It is with this latter we have especially to do in treating of the physiology of vision. Without entering into a detailed consideration of all the laws of refraction, we will state that when the refracting body has a certain form, which we call a lens, all the rays coming from any one point of an object are, after refraction, brought together in another point. Such a lens is shown in the accompanying figure.

Fig. 1.

All rays proceeding from the point A are, after their passage through the lens, united in the point *a*, and all rays proceeding from the point B are, after refraction, united in the point *b*, and rays proceeding from all points between A and B are united at points between *a* and *b*. The result of this is that in *ab* we have an *image* of the object AB. There are two peculiarities of this image to which I want to call your attention. The first is that it is much smaller than the object AB, and the second is that it is turned upside down. Now, when we come to regard the eye as an optical instrument, we will find it to differ in principle in no essential particular from this simple lens. The whole function

of the eye, from an optical point of view, is to form a small, clearly defined, but inverted image of external objects on the expansion of the optic nerve. We will now proceed to see in what manner it does this. This leads us, first, to a brief description of the general anatomy of the eye.

As the human eye has to be moved in various directions, independent of the movements of the head, it must be more or less globular in shape. It is thus allowed to fit more easily in the bony orbit in which it is encased, and the six muscles which move it can more readily control its motions. The ball of the eye is a hollow globe containing the lenses necessary for producing images of external objects and the expansion of the optic nerve on which these images are to fall.

There are certain physical conditions which have to be fulfilled in order that the image produced by any optical apparatus shall be clear and distinct. We will take the photographer's camera as an illustration. In the first place we find that the whole apparatus is encased in a box for the protection of the more essential parts. We observe further that this box is lined with black in order that no light shall be reflected from its sides that will mar the distinctness of the image formed by the lens. The lens is placed in front, and at the back there is a screen of ground-glass on which the image formed by the lens falls. When sitting for your photograph you will also have noticed that the operator was at great pains to properly focus the instrument so that the image should be clearly formed on the ground-glass plate at the back, and if you take the pains to examine his instrument you will find just behind the lens a black diaphragm with a circular hole much smaller than the lens. This latter is for the purpose of cutting off those rays which pass through the parts of the lens near the edge. These rays, unless the lens is ground in the most accurate manner, add nothing to the distinctness of the image, but, on the contrary, detract from its clearness of outline.

All these conditions are carefully fulfilled in the eye, as you will see by reference to the accompanying diagram.

Fig. 2.

You have in the first place the outer box or shell in the sclerotic coat, (S,) which is a tough membrane forming the posterior four-fifths of the ball. The anterior, one-fifth, is formed by the cornea, (C,) which is only a continuation of the sclerotic with the remarkable and highly important difference that it is transparent. This cornea being a curved surface, acts upon the light in the same manner as the lens in Fig. 1, and forms one of the two refracting surfaces which produce the images of objects in the external world upon the expansion of the optic nerve (On) at the back of the eye called the retina, (R.) The other refracting body is the crystalline lens, (L.) The iris (I) represents the diaphragm, and the hole in it is the pupil. The choroid coat, (Ch,) while holding the greater part of the blood-vessels which nourish the eye, also contains a large quantity of pigment, which serves the purpose of the black lining of the photographer's camera. We have thus all the essential parts of a perfect optical instrument, and by the large majority of persons the eye is considered the most nearly perfect of all instruments of its class from a merely physical

standpoint. This is, however, a great error. Considered as an optical instrument, whose function it is to form the clearest possible image, it is defective in almost all its parts, and does not begin to approach the best work of the same kind as done by man. Helmholtz, the great German physicist, has said that if an optician were to send him an instrument so badly constructed as the eye, he would return it to him with a severe reprimand for his carelessness. But we must bear in mind that the eye is an organ of sense as well as an optical instrument, and with all its defects, is capable of rendering us most efficient service.

As I have said, the function of the eye proper is to form clearly-defined inverted images on the retina. The impression or changes produced by this image are conveyed to the brain by means of the optic nerve, and are there converted into a sensation. A confused image will cause a confused sensation, and a clearly-defined image a corresponding sensation. It is, therefore, of the highest importance that we always have retinal images whose outlines are sharp and distinct. This is very easily accomplished when the object and the retina occupy certain relative positions to each other. It is one of the laws of optics that when the object is at a certain distance (within specified limits) from the lens the image will be formed at a certain distance from it on the other side. If the distance of the object is changed, the distance of the image from the lens will also be altered.

Now, in using the eyes, we look at objects within a few inches of us and also at those at immense distances. The range of accommodation, as it is called, extends from four inches from the eye to infinity. If we are to have clearly defined images of all objects in this extensive range some change must take place in the eye corresponding to the change in the distance of the object. Now this can be accomplished in one of two ways—either by a change in the distance between the lens and the retina, or by an increase in the curvature of the refracting surfaces. The first of these cannot be readily accomplished, because the eye cannot be made longer, (though it was once supposed that it

could.) The adaptation or accommodation of the eye, therefore, for distinct vision at different distances is affected by the other method; that is, by a change in the curvature of one of its two refracting surfaces. It has been abundantly demonstrated by observation that this change is effected by an increase in the curvature of the crystalline lens, brought about by the action of a muscle situated on the interior of the eye called the ciliary muscle, (Cm, Fig. 2.) By the contraction of this muscle the lens is rendered more convex, and objects lying nearer the eye have their objects formed more clearly on the retina. A reference to the diagram (Fig. 3) will show how this is accomplished. When the object is situated at A the image is formed on the retina, R, at *a*, when it is at B it is formed behind the retina at *b*. In order, therefore, when the object is at B, to have its image at *a*, the lens, L, must be made more convex, as shown by the dotted line.

Fig. 3.

It is this failure of the power of accommodation or adaptation of the eyes to objects close at hand which constitutes *presbyopia* or old eyes. With advancing age the ciliary muscle becomes stiff and less powerful, and the lens becomes harder and alters its shape less readily, and the consequence is that near vision is rendered less perfect. This is remedied by placing in front of the eye a lens which represents the power that has been lost by the crystalline lens. Quite the contrary of the generally accepted belief the eye does not become materially flatter with age.

We have now the image of the external object pictured clearly and distinctly upon the expansion of the optic nerve at the bottom of the eye, and with this the whole of the function of the eye as an optical instrument is ended.

In a general way the eye is considered by the large majority of persons as being *the* organ of vision, whereas, in truth, it is only *one* of the organs concerned in bringing about the sensation of sight. The eye may be anatomically in a perfectly healthy condition, and the images of objects may be formed with the greatest clearness and distinctness on the retina, and, yet, the power of seeing be wanting. The image formed on the retina produces only an *impression*, and this must be converted into a *sensation* before the act of vision is accomplished. This conversion takes place in the brain. That there is a certain portion of the brain which presides over the function of vision, and turns all the impression sent to it from the retina through the optic nerve into sensations, seems clearly demonstrated by numerous experiments on the lower animals. The eye, therefore, is only one of the instruments of vision.

Let us now proceed to inquire what it is we learn by the act of seeing—what knowledge of the external world is brought to the mind through the medium of the eye. We learn, first, the position of objects in space; their distance from us and each other; their form, size, and color.

It may be premised that very little of our knowledge obtained by the sense of vision is furnished alone by the images formed on the retina. In the development of the intellect the senses of sight and touch go hand in hand. In fact some recent speculations seem to point to the fact that sight is only a highly developed sense of touch. Be that as it may, this important fact is clearly established, that the sense of sight is an educated sense. It is not in-born; it is not instinctive, at least, in the higher forms of beings. Every child that is born into the world must learn to see for itself. As soon as an infant opens its eyes an image is formed on its retina, but that conveys to its young mind no definite knowledge except, probably, as to outline. Suppose, for example, a rattle, with a ring at one end, and a ball at the other, is held before it. The image of this object is formed on the retina, but it is upside down, as are all retinal images. How then is the child to learn the true re-

lation of this object to itself? This is a question which puzzled philosophers for a long time, and many explanations were given to account for it. By some it was supposed that in some way the image was "righted" before it reached the retina, by others, it was thought that it was turned right side up on its passage from the retina to the brain. But it is by no means necessary to assume any such mysterious processes. The explanation, when we once find it, is simple enough. The image, as we have before remarked, is undoubtedly formed upside down on the retina. But we must bear in mind that this image only produces an impression—the interpretation of this impression is made by the brain through the faculty we call the judgment. Now the judgment is often the result of several impressions, received, it may be, from several different sources. In the case of the rattle, the impression made by the image must be verified by the impression of touch. The infant reaches out its hand and finds that the globular end of the rattle corresponds in direction to its feet or downward, while the ring end corresponds to an upward direction or towards its head. It does not make any difference that the lower or round end of the image corresponds to the upper part of the object, and *vice versa*. The position of the retinal image is a matter of no importance, so long as the judgment, guided by touch, places the object in its proper relation with the individual and surrounding objects. Physiologists call this placing of objects properly in space the "law of projection," which, being interpreted, means that all impressions made on the upper parts of the retina are "projected" or referred downward, and all impressions made on the lower parts of the retina are projected upward; and as the relative position of the objects in the external world are in no wise affected by their inverted images on the retina, no confusion can arise.

The same principle applies when we judge of the distance and size of objects. The size of a retinal image gives us no idea whatever of the size of the object or its distance from us. These two ideas are inseparably connected in the

mind. The distance of an object from us gives us important data for forming judgment as to its size and the size of it if known, enables us to form an idea of its distance. You will readily see the truth of this, when you know that a five cent piece, held a few inches from the eye, forms as large a retinal image as the sun which is many millions of miles further off. Physiologists would tell you that they both subtend the same visual angle. So if we wish to have a definite idea of the actual size of an object we must know its distance from us; and, on the other hand, in order to judge of the distance of an object, by the size of the retinal image, we must know its size as compared with other objects. In the judgment of distance, however, there are other factors not to be overlooked. One of the most important of these is what is called the "muscular sense." In looking at objects close at hand we bring into play the accommodation of the eye which, as I have already told you, is brought about by the action of the ciliary muscle. The nearer objects are to us the stronger must be the action of the muscle in order that we see distinctly, and we come naturally to associate a strong effort of the accommodation power with nearness of the object. The amount of convergence of the two eyes, which is necessary in order that both be fixed upon the same object, also furnishes us with important knowledge of the distance of objects from us.

We come now to consider one of the most remarkable attributes of objects, a knowledge of which is given us through the eye. We allude to that wonderful quality called color. In the strict sense of the word, however, no object is colored. Color is a property of light, while those objects which appear to us colored simply decompose the light falling on them into its different color constituents, sending to the eye some one or more and absorbing the others. For ordinary purposes, however, it is more convenient to consider color as belonging to the object, but we must bear in mind, at the same time, that each color is represented physically by a certain number of vibrations of the luminiferous ether. Thus, 451 million million vibrations of the ether in a

second of time represent the color we call red, while 789 million million vibrations correspond to violet, and so on. An object we call red, therefore, sends to us from the white light falling upon it those waves of the ether which make 451 million million vibrations per second. All the other wave lengths of the ether are lost, and most probably by having their motion converted into a molecular vibration of the substance of the object.

When we call to mind the great number of separate colors and the infinite variety of their shades, which we recognize as distinct sensations, we at once appreciate the extraordinary delicacy of perception by the visual apparatus.

The satisfactory explanation of color perception has always been among the most difficult problems with which the physiologist has had to deal. The theory on this subject which has held the longest sway over the largest number of minds is that of Young, as revived by Helmholtz. Until within the last few years few or no physiologists had the temerity to doubt the sufficiency of this hypothesis.

This theory starts out on the basis that there are three fundamental or primary colors, by the proper admixture of which all other colors and shades of colors can be produced. It is now the popular opinion, which was formerly upheld by scientific authority, that these so-called primary colors are red, yellow, and blue, because from a mixture of *pigments* of these colors the painter can produce a large number of the colors he finds of use in the practice of his art. When, however, we come to deal with the pure colors of the spectrum we find that these are not the fundamental colors. It has been found that from the mixture of spectral red, green, and violet, all the other colors of the spectrum can be produced, and, also, that when these colors are mixed in due proportion white is the result. For this reason, red, green, and violet have been accepted as the primary colors by most modern scientists.

Newton believed that the particles representing the individual colors (according to his emission theory) affected the retina "according to their nature and bigness," but Young

thought it impossible that the retina should be able to receive or the optic nerve should carry so many separate and distinct impressions to the brain. He, therefore, assumed that there were in the retina three nerve fibres which were affected principally by the wave-lengths of ether representing red, green, and violet. These fibres we will call the red fibre, the green fibre, and the violet fibre. When all of these fibres are affected in equal proportion the sensation produced is white, the absence of all sensation is black. When the red fibre is affected we have a sensation of red; when the green fibre is affected the sensation is green; when the red and green fibres are affected together the sensation is yellow; and so on for all the colors with their combinations and shades. Now this is all very simple and plausible. It is true no one has ever seen the fibres, but, so much has to be taken for granted in this department of scientific investigation, that this point might readily be conceded if there were no other obstacles in the way of an acceptance of the theory. Nearly all the phenomena of colored vision can be accounted for on this hypothesis if we so modify it as to allow of some action on both the green and violet fibres by the red rays, and some action on the green by the red and violet, and on the violet by the red and green. For myself, this necessary admission destroys the simplicity and beauty of the hypothesis, for I hold that the phenomena of vision, when thoroughly understood, will be found to be extremely simple in their character and in keeping with the known laws of light and its action on simple bodies.

But the great and insurmountable objection to the hypothesis is that it cannot account in a satisfactory manner for all the phenomena of color-blindness. An acceptable theory in regard to the function of an organ in health must account also for all the derangements of that function.

Without entering into any details, it may be briefly stated that there are some phenomena presented by the color-blind, which cannot be satisfactorily explained by the Young-Helmholtz hypothesis. Physiologists are, therefore, becoming dissatisfied with it, and are seeking for one which shall

be more in keeping with known facts, and more in accordance with operation of analogous functions in the human body.

The theory of Prof. Hering, of Prague, has received most attention from those who have been bold enough to reject the hypothesis of Young.

This theory presupposes the existence in the retina of three chemical substances, which, on account of their presumed functions, are called the *red-green* substance, the *blue-yellow* substance, and the *black-white* substance.

An action of light on the red-green substance, which tends to decompose it, produces red; while an action which tends to regenerate it produces green. A decomposing action of light on the blue-yellow substance causes a sensation of yellow; a regenerating action, the sensation of blue; while a destruction of the white-black substance produces white, its regeneration black. According to this theory there are three pairs of opposing colors, (including white and black,) and the fundamental colors are four, red, green, blue, and yellow, and the so-called complementary colors are in reality antagonistic. Thus you see Hering's theory is more complicated than that of Young, likewise demands the acceptance of unproved and unprovable postulates, and makes even greater draughts upon our scientific faith. It has this advantage over its rival, however, that it explains in a much more satisfactory manner some of the phenomena of color-blindness.

The fundamental objection to this theory, as to that of Young-Helmholtz, is that it presupposes the existence of new tissues, the like of which are not found in any other part of the human body, and novel reactions of these tissues to light. It may be accepted as a law of universal application that Nature always works in the simplest manner possible, and we have no right to suppose that the function of vision forms any exception to the rule. Is it possible to account for the perception of colors in a simple and direct manner? I think it is, and that, too, without doing any violence to laws, the existence of which has been estab-

lished by proof as positive as science can furnish us. I have endeavored to do this in a paper read before the Philosophical Society of this city, in December, 1880.

It would not be pertinent, at this time, to enter into an elaborate exposition of this theory. Let it suffice to say that the two fundamental facts on which it is based are: 1st. The evidence which comparative anatomy and physiology furnish that the eye is but a highly specialized nerve of common sensation. It is a fact which has been thoroughly well established by observation that certain of the lower animals are affected by light over the whole extent of their external surface. As we ascend higher in the scale of existence the differentiation of function becomes greater, and while the grosser effects of the ether vibration are still felt in the form of heat on the surface of the body, the finer vibrations are appreciated only in certain restricted localities known as eyes; for it is a fact which is disputed, I think, by no one that heat and light are both due to vibrations of the same ether, differing in degree only, and not at all in kind.

Prof. Preyer, of Jena, has, within the last few months, advanced very similar views, and shows that the sense of heat and the sense of sight bear a very strong analogy to each other. The second fact is the reaction of simple substances to light, as manifested by a change in their molecular structure. It has long been known that certain colors have greater chemical powers, for instance, than others. The so-called actinic power of blue or violet is greater than that of yellow. This is only a short method of stating the fact that the change in the molecular structure of the affected body is much greater by light rays of short-wave lengths than it is by light rays of longer-wave lengths. The action of light on the metal selenium, and on other substances used in the construction of the photophone, is an example more to the point. Not only is the electric conductivity of these substances modified by slight changes in the *intensity* of the light waves, but Prof. Bell has found that this variation in conductivity, which only represents change

in molecular structure, is also different for the different *colors*. Moreover, the effect of this change in molecular structure is conveyed to great distances through other media, and there makes itself manifest under the same or some other form.

It is thus evident that in the inorganic world the light rays do produce different affects, as manifested by molecular change, according to their different wave-lengths. We have only to apply this law to the action of light on the retina to have a theory of colors at once simple, and strictly in accordance with known principles, and without the necessity of inventing new tissues or extraordinary reactions of tissues to light. In this theory variation in sensation will have its basis, not in complexity of tissue, but solely in the varying action of the affecting agent.

In accordance with this hypothesis we have only to suppose the retina to be a body whose molecular structure is so delicately fashioned as to allow it to respond promptly to the slightest variation in the wave-lengths of light rays. We know that up to a certain point we can discriminate between fine shades of *intensity* of light. The educated eye of an artist can detect as minute differences in shading as he can in colors. This we must suppose is due to the judgment which has been educated to discriminate between small differences as to *quantity*, and there can be no reason for not supposing that we can learn in like manner to distinguish between small differences in quality as manifested in the slight alteration in the molecular arrangement of the retina brought about by the different colors. Every impression, therefore, produced by each color will be conveyed independently of other impressions to the brain, and will there be turned into a distinct and individual sensation. But even in this theory there is no necessity for supposing that all the color sensations are primary. We can have here, as in the other theories, a mixture of sensations in the production of some colors, and the numerous combinations which are known under the name of secondary colors. Purple, for example, will be the sensation resulting from a combi-

nation of the two sensations of red and blue. The same holds true for the browns, and the various other tints of that order. The combination, however, is made in the brain and not in the retina.

We have now finally traced the changes which enter into the production of the function of vision to the brain. If these changes stop anywhere short of there, we have no sensation, no light. In fact, it is not vision at all, for it is the brain which overrules all, and transforms impressions into thought and consciousness. We see—not with the eye—but with the brain—the eye being only one of the instruments which the brain uses to bring to it knowledge of the changes which take place in the outer world. This knowledge it arranges and classifies under the superintendence of the judgment, and we give to it the comprehensive name of vision. This leads us to what was, for a long time, considered the boundary not only of our actual knowledge, but even of legitimate speculation. Consciousness was considered not only a *terra incognita*, but also a *terra sacra*, within whose hallowed precincts even the boldest materialist dare not venture with his unholy atoms and molecules. But true science is always fearless, and pushes its way with irresistible force into every avenue where honest investigation offers for its labor the smallest modicum of new truth.

Anatomical science has traced, by its numerous and patient dissections, the optic nerve to its termination in a certain portion of the brain. As nothing in the workings of Nature is ever purposeless, we are bound to believe that as the nerves always end in the same part of the brain, the brain in that immediate vicinity must have some connection with transformation of light waves into vision. Then the vivisectionist came forward with that knife, whose supposed cruelties have been so eloquently sung by a thousand sentimental tongues, and removed that particular portion of the brain from the living creature, and the animal became completely blind. Thus one more stone of truth was added to the slowly growing temple of human knowledge, and to-day every physiologist will tell you that the

sense of vision resides in the cortical substance of the posterior cerebral lobes.

But the human mind, ever unsatisfied with its present knowledge, inquires still further, and asks what are the alterations which take place in that particular portion of the brain when the changes wrought by the light waves on the retina are brought to it through the medium of the optic nerve?

Let us, for a moment, look at it dispassionately and without prejudice, as becomes all seekers after the truth. Let us remember in the first place that we have been all the while dealing with matter. The object to be seen is material, the ether, if it exists, must be material; and we know that the optic nerve and retina are matter, and the brain is a substance analogous to these in anatomical structure.

If we take a self-luminous body as the object, we know that molecular change, in the form of motion, forms the first link in the chain of sequences of which we spoke at the outset of this lecture as necessary for the function of vision. These motions are communicated to the surrounding ether, and by it are carried to the retina. Have we any right to suppose that the molecular motion stops there? Certainly not. There is no fact yet demonstrated which militates against it, and in this hand to hand warfare of Science against the hidden secrets of Nature we claim all to be for us which is not positively against us. On this principle, therefore, we are amply justified in assuming that the ether has only been the medium of transference of molecular motion from the body to the retina. This motion is then transferred through the optic nerve to the demonstrated center of vision in the brain. Does molecular change in the form of motion end even then? Having followed it thus far we can see no satisfying reason why it should. And the last link in the chain which is discernable by our short-sighted vision is a change, manifested by a form of motion in the ultimate molecules of the brain. How this motion of the molecules is converted into consciousness is a problem for the solution of which we have not even the

rudiment of a faculty. We only know that the phenomenon began as motion, and that as motion it ended. But beyond—ah, beyond—is an impenetrable darkness. We emerged from an eternity of ignorance, we end at the brink of an eternity of the unknowable. In the infinitesimally short span between these two mighty eternities we are permitted to examine into the workings of Nature's laws, to follow out their relations to each other, and apply them, as far as we are able, to the explanation of the phenomena by which we are surrounded; but of the origins of these laws we are, as scientists, in utter ignorance. We have not been provided with a power to grasp at even the beginning of an idea which would lead us nearer a solution of these problems than we now are. And as at the beginning so at the end. There are some things which are not only unknown but unknowable. It is utterly impossible that we can ever know how light waves or sound waves are converted by the material organ of the brain into consciousness and thought. That this is accomplished by the brain we know, and that it is through a change in its molecular structure admits hardly of a doubt, but there we must pause. We have reached the limits of our possible knowledge, and from any attempt at penetrating the darkness beyond even the imagination shrinks, overwhelmed by the consciousness of its utter powerlessness and incapacity.

And now, ladies and gentlemen, we have finished all we designed to tell you of what we know of one of the most important and wonderful faculties with which we are endowed, and we have also given you some conception of the amount we do not know, and from the very nature of things can never know. This latter, as compared with the former, is immense, but when we come to consider how wonderful and surprisingly beautiful it all is, we can only be glad that we are permitted to know and enjoy as much actual knowledge as we do. I could have confined myself, in these remarks, to a description and experimental demonstration of some of the beautiful laws of light and vision which science has unraveled out of the eternal mystery, and we could have

boasted of the numerous secrets wrested from nature's hidden store-house of facts by the patient and persistent inquirers in this department of scientific investigation. But true science never exalts itself—is never puffed up. It is as diligent in seeking out error as it is in finding a new fact. It holds no opinion to be final. The mind of the true scientist is always in a plastic condition, ready to take that form and shape which well-founded data warrant, and is ever willing to change it as the facts demand. The scientific gentlemen who have preceded me in this course of lectures have laid before you knowledge gained from many widely-differing fields of research, but they have never insisted on the acceptance of a single opinion that was not laid in facts, or was not in strict accordance with well-demonstrated laws. Theories and hypotheses are, it is true, not to be discarded because in the present imperfect state of human knowledge positive ideas are often impossible, but only that one should be accepted which comes nearest to the truth as we know it. Dogmatism and bigotry should find no place in the intellectual make up of the scientific mind. And if I understand aright the purpose of these Saturday scientific lectures, it is not only that you shall become acquainted with the discoveries and advances of modern science—most of which you could learn by a study of books and the reading of the scientific periodicals of the day—but that you might feel and understand the attitude of Science towards man and his intellectual and moral advancement. The time was when science was considered the greatest enemy of mankind, when scientists were imprisoned and put to death, and to seek the truth as it was to be found in Nature was considered blasphemy. But the new era is dawning, and it is the scientist who has opened up the way. The watchword of the hour is Truth! and to whom is this more dear than to the man of science. His whole life is spent in an untiring search after it. The objective point of his every action and thought is the truth. He never fears what effect any new fact may have upon any preconceived opinion, however dear it may be to him. He only asks, is it true? The truth in nature is the idol of

his affections, and he loves it with a love surpassing that of woman. We do not claim for the whole body of scientific men such single-mindedness of purpose, but we do claim that the tendency of scientific investigation is to develop these higher and better faculties of man. What more completely rounded character can be found that was embodied in him whose recent death has carried a sense of irreparable loss to the heart of the whole civilized world. In after ages when the world makes up its roll of great and perfect men, the name of Charles Robert Darwin will be found high on the list. Indifferent to the scoffs and jeers of his detractors, he kept his eye single to the eternal verity of Nature. With that he was content, and in it he found his all-sufficient reward.

And when a few days ago he was carried to his last resting place in the mausoleum of England's great dead, and placed by the side of her immortal Newton, science might justly consider that her hour of triumph had come, and that she had won the recognition she claims. That the man whose theory on its first promulgation was considered a by-word of reproach, should have his name mentioned with reverence, and his greatness and worth acknowledged from places which denounced him but twenty years ago, is a spectacle which is without a parallel in the history of science.

It may be truly said of him, as one of our poets has said of our beloved Wyman, that it was his high privilege—

“ To feel mysterious Nature ever new,
 To touch, if not to grasp, her endless dew,
 And learn by each discovery how to wait;
 To widen knowledge and escape the praise
 Wisely to teach, because more wise to learn;
 To toil for science, not to draw men's gaze,
 But for her lore of self denial stern;
 That such a man could spring from our decays,
 Fans the soul's nobler faith until it burn.”

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