DEPARTMENT OF THE INTERIOR,
BUREAU OF EDUCATION.

OUTLINES

FOR A

MUSEUM OF ANATOMY,

PREPARED FOR

THE BUREAU OF EDUCATION

BY

R. W. SHUFELDT.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1885.

DEPARTMENT OF THE INTERIOR,
BUREAU OF EDUCATION.

OUTLINES

FOR A

MUSEUM OF ANATOMY,

PREPARED FOR

THE BUREAU OF EDUCATION

BY

R. W. SHUFELDT.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1885.
5005 M A

CONTENTS.

DEPARTMENT OF THE INTERIOR,
BUREAU OF EDUCATION,
Washington, D. C., June 18, 1885.

SIR: The following paper on "Outlines for a Museum of Anatomy," written by Robert W. Shufeldt, U. S. Army, exhibits clearly a systematic comparative arrangement of anatomical parts, structures, and forms in any museum, large or small, and, incidentally, the reasons for such an arrangement.

A perusal of the paper will show that the method, contents, and arrangements advised would be calculated (1) to display the unity of nature; (2) to simplify and vivify instruction in anatomy and kindred branches in elementary as well as in professional schools; (3) to minimize the expenditure of both time and money for the care and increase of such collections; and (4) to serve as a sort of model for the scientific and comparative care, in museums having other purposes or of more general character, of many sorts of articles, and particularly those of human contrivance.

The paper as a whole would be of great value to those occupied or interested in the construction, collection, and arrangement of museums attached to medical colleges, and to schools or societies promotive of medical or scientific education. It is therefore recommended for publication.

Very respectfully, your obedient servant,

JOHN EATON,
Commissioner.

The Hon. SECRETARY OF THE INTERIOR.

Publication authorized:

H. L. MULDROW,
Acting Secretary of the Interior.

OUTLINES FOR A MUSEUM OF ANATOMY.

CHARACTER OF PRESENT ANATOMICAL MUSEUMS.

About three years ago I found myself alone in the anatomical museum of a prominent medical college in a famous southern city of one of the Gulf States of our Union. There I beheld the objects that had been collected, apparently during a number of years, to illustrate the sciences of anatomy and physiology. One could picture to himself how the students of class after class, and the graduates of this college, each and all had passed many times through these three rooms, with the view of studying these models and casts, and jars of specimens.

Ranged down the center of the largest room one saw models of men, above the size of life; in one instance, stripped of his integuments and standing, like some ancient gladiator, with his hand aloft, to show the superficial layer of muscles to advantage; in another, these have been cut away, and the deeper layers are shown. Here, again, we see superb French composition casts, demonstrating the anatomy of woman and the infant, and there skeletons, not a few, of all three. In the cases are manikins, models of the organs of special senses, and the visceral systems. Again, we pass to the "awkward squad" of dried up conventional mummies, which are intended to illustrate the circulatory system. Interspersed here and there we find all those anatomical odds and ends that such places almost invariably yield.

In another and smaller room we gaze upon a few skeletons, dilapidated in the extreme, of the "lower animals," while in the cases, huddled together without any attempt at classification or natural arrangement, we observe a hundred or more various-sized glass jars, containing reptiles, fishes, and other things too numerous to mention, even if we could discern their character through the smudgy receptacles that contain them.

Indeed, the contents of the anatomical hall of this old medical college furnish us with abundant material for thought. In spite of the uninviting appearance of the place and the dust upon all the objects, there had been a great deal of money and labor spent here, as many of the models were expensive and undoubtedly of foreign make. Now, what idea, respecting our present knowledge of anatomy, would a student of the subject derive from such a collection? Hardly any worthy of mention.

Again, if the entire thing could be closed, sealed, marked with the date of the present year, and passed down to posterity, and if future generations had it only to judge from, how would they regard the nineteenth century anatomists? About, I think, as we now regard those of the fourteenth century.

The college to which I allude in the above paragraphs does not stand alone in this regard, for we find equally defective and highly antiquated collections in many other institutions all over our country.

As a rule, these exhibitions, and to them I do not at present remember a single exception, are purposeless as to what they should in reality teach, and totally unfitted to give any just conception of our knowledge of anatomy and physiology at the present time. They are neither instructive nor representative. They range all the way from collections got together through the modest means of some small college, to the more elaborate displays of anatomical museums having abundant resources and facilities, where no such reason as poverty can be pleaded in extenuation. Not a few instances might be pointed out in our larger cities, where thousands of dollars have been devoted to anatomical collections, either in the purchase of finished specimens or else expended for the labor of preparing others. Unhappily, the result is generally a mass of material, consisting of heterogeneous and non-systemized groups of mammals, worse prepared birds, an absolutely useless shoal of semi-skeletonized fishes and reptiles, with a meager representation of their soft parts all the way round.

It will be my endeavor in the present article to lay before the reader, in as clear and concise a manner as possible, all that a modern museum of anatomy should be. I shall feel myself perfectly at liberty to discuss any question that may bear, however remotely, upon this subject, though it is my intention to touch upon some points quite lightly, while in other cases I shall pass into the details with all the thoroughness of which I am capable.

Let me, at this point, especially impress one thing upon the mind of my reader, and that is, in a number of cases there have been moneys enough expended in building up anatomical collections in this country to procure twice over, in any single instance, all that I here propose to have represented in an equally extensive collection. Should what I here set forth prove to be of assistance to curators in charge of, and intending to remodel, collections already in existence, or a guide to those who have in view the commencement of a museum of anatomy, then I shall feel my labors have been well repaid.

GENERAL OUTLINE OF A MODEL MUSEUM AND ITS CORPS OF ADMINISTRATION.

Upon the subject of the building that is to contain our collection, I intend to say but little, as such a structure must be modified essentially by so many varying circumstances. In the vast majority of cases, no

doubt, it will be a wing thrown out from some edifice devoted to other purposes in connection with the institution.

Such necessary and highly-important matters as lighting, method of heating, and having the entire structure fire-proof, fall within the province of the architect and the means of the institution involved. The halls of the American Museum of Natural History in New York City meet, in my estimation, nearly every end in view. They are wonderfully perfect in their way, and well adapted in all particulars to exhibit a collection. Very important are the cases and their arrangement. Of course these will also vary greatly with the character of the specimens they are to contain. Some will be intended to stand in the middle of a room, while others are to be against the wall. Osteological subjects should have a dark background, royal purple being one of the best colors for this purpose. It is an advantage to have the cases on rollers in many instances, so that they can be moved. Good examples of this pattern are to be seen in the U. S. National Museum at Washington. In these the specimens are exhibited on both sides, and the midpartition furnishes the surface for the purple background of each. Large skeletons of animals are better without glass cases, and should stand in the hall in their appropriate places. Under no circumstances should many specimens be huddled together in any single case. It is impossible to study them under such circumstances, and only confusion can result. The more important and medium-sized objects should be displayed on a plane about on the level of the line of vision of a man standing. The method of casing such objects as disarticulated skeletons I shall speak of hereafter.

Many museums of anatomy possess a library of greater or less proportions; when this is the case they are extremely fortunate, as the usefulness of the institution is fully tripled thereby. Such a library should contain a copy of every work that has been written upon the subjects of anatomy and physiology, and should subscribe for all the current literature that pertains to the same. In addition, it should have upon its shelves many works treating of kindred subjects, as special zoological monographs, proceedings and transactions of learned societies (native and foreign), and a full series of those subjects in medicine and surgery where anatomy and physiology have been strictly applied.

I have often pictured, with pleasure, such a library erected as a wing to the museum and having direct and easy communication with it, which can always be obtained by having both halls on the same floor. The arrangement would be complete if the two could be connected in a similar manner with a third large and airy apartment or hall, in which special anatomical material, such as disarticulated skeletons, could be kept for the use of privileged students, authors, and investigators. This room should be made particularly inviting and comfortable, and in it strict quiet should be maintained. Here, too, should be ranged, at convenient distances, suitable tables for those who are at work, having one or

two lock-drawers for such things as they may have in use in connection with their studies or investigations, and a rack to hold any books that the student has been allowed to take from the library.

Of the corps of administration of such a museum and library I intend to say but little. It should include, of course, the director, with his staff of librarian and others, two or more curators, the janitor and attendants, and an intelligent anatomist and his assistant. Fortunate, indeed, is such an institution, if the strange way affairs sometimes turn in this world has allowed it to find a man at its head thoroughly competent to hold the position. Such, alas, however, is not always the case. In one instance a gentleman whom I knew very well—a very able man in many respects—had been in charge of a museum of anatomy for many years. This friend in conversation once made the remark to me that he thought the law of evolution was a terrible one to establish, and that for himself he did not believe in it; that in a hospital of which he had had charge for several years he had seen in the same ward, in adjoining beds, two patients, each contending against an attack of phthisis—one man was strong and robust at the time of the invasion of the disease, while the other was feeble and puny—and he saw the one possessing the iron frame and powerful constitution die, while the other recovered. It was useless to talk to him about such a thing as the survival of the fittest. It was an easy matter for me to conjecture the condition in which I would find the museum of anatomy over which such a mind as that held sway. I was not disappointed. My diary contains accounts of several similar instances, but this one illustration will suffice my purpose here.

LAWS WHICH SHOULD GOVERN THE FORMATION OF A COLLECTION.

We have now arrived at that point in the discussion of our subject where attention must be directed to the collection proper. This demands both consideration as an entirety, as well as a description of the individual specimens. The ends to be attained by the former necessarily depend upon an intelligent selection and arrangement of the latter.

The chief aim of the collection, as a whole, is to present to the mind of the student or visitor as clear a conception as possible, so far as our knowledge goes, of the subject of morphology, or the structure of animal forms, in all its bearings, and, to the full extent to which our ingenuity will carry us, the fundamental principles of physiology.

To do this in a proper manner, every specimen or series of specimens must be arranged throughout, wherever it can be conveniently accomplished, in accordance with our present understanding of the laws of evolution and consecutive development. If we could classify, in cases, models of the *entire anatomy* of *all* the animal forms now living upon this earth, and specimens of the remains of all those confined in its crust, this would be the arrangement they would naturally fall into in any

event. Our museum must necessarily, however, present many, many gaps in such an all-absorbing scheme as this; still a very great number of examples illustrating this law can be presented, as I intend to show further on—a number quite sufficient to enable one to appreciate its presence at every step and feel its truth, and see its wonderful beauty throughout. The arrangement of the specimens in a museum of anatomy and physiology in the future upon any other plan will simply defeat the objects of the institution, and render it almost a useless place of resort for any one whose object it is to gain an idea of the broad principles that underlie morphology.

Even if it were proper to do so here, I would no more think, at this day, of undertaking to demonstrate the truth of the law of evolution, or make any apology for it in the present connection, than I would essay to do the same for Newton's laws of gravitation, had they formed a part of my subject. Indeed, I regard it very much in thesame light; for, as Huxley says:

> An inductive hypothesis is said to be demonstrated when the facts are shown to be in entire accordance with it. If that is not scientific proof, there are no merely inductive conclusions which can be said to be proved. And the doctrine of evolution, at the present time, rests upon exactly as secure a foundation as the Copernican theory of the motjons of the heavenly bodies did at the time of its promulgation. Its logical basis is precisely of the same character,—the coincidence of the observed facts with theoretical requirements.[1]

So far as we now comprehend them, the laws of evolution as they apply to morphology, physiology, and psychology, are sufficiently well known to all cultured and reading people to obviate the necessity of my presenting ever so brief a definition of them here. Moreover, much that refers to the subject I trust to make clear when we come to the discussion of the separate specimens.

The second law that the collection as a whole will be selected and arranged by, and designed to illustrate, is, *that in order to obtain a correct knowledge of the anatomy of any form we must have a general conception of the structure of all other forms in nature, and, as near as possible, an exact knowledge of those more nearly related to any special one we intend to study.* In the case of man this is absolutely imperative, and it is the only road through which we will ever gain an exact knowledge of his structure. I not only refer to his gross anatomy, but particularly to the histology of man's own form. Precisely the same methods of investigation apply to the subject of physiology—a science, so far as our present knowledge of it goes, that is still in its infancy.

I will present here but one instance of the operation of this law and what it leads to. Take the subject of medicine and surgery: *medicine and surgery progress and become perfected* pari passu *as our knowledge of pathology increases; our knowledge of pathology rests entirely upon our knowledge of physiology, and, as a rule, advances with it; we cannot know*

---

[1] Huxley, Thomas H. *Lectures on Evolution* delivered in New York City, in September, 1876. Published in various places.

physiology unless we know structure, and in the case of man our knowledge of his structure only advances as our knowledge of the anatomy of other animals and the significance of general morphology become more complete. Consequently the progress of medicine and surgery depends through all time upon the extent of our knowledge of general morphology, or organized forms upon the earth.

Every physician, then, who has any regard for the progress of his profession should, wherever the opportunity offers, do all in his power to advance as much as possible the study of general morphology, and those great and universal principles of physiology to be found in organic nature.

This must explain to the minds of many the constantly increasing reference, in the more important and progressive articles throughout medical literature, to what we learn from our studies of the structure of the lower animals, and, also, why we find in our museums of anatomy certain collections of the skeletons of this class of animals. In either instance they are to be regarded as the first dawning of that light that comes from ages of study in biology, which now flashes upon the road of another profession as its most important guide to progress. As a very able writer puts it—

After centuries of intellectual conquest in all regions of the phenomenal universe, man has at last begun to find that he may apply in a new and most unexpected manner the adage of antiquity, "Know thyself." For he has begun to perceive a strong probability, if not an actual certainty, that his own living nature is identical in kind with the nature of all other life, and that even the most amazing side of that nature—nay, the most amazing of all things within the reach of his knowledge, the human mind itself—is but the topmost inflorescence of one mighty growth, whose roots and stem and many branches are sunk in the abyss of planetary time.[1]

So far as the treatment of human disease is concerned, I must believe, that if at any time in the infinite future—so infinite that present man may have assumed other shapes—disease is to be eliminated, it will *not* be through the agency of drugs, but through a cumulative knowledge of the intimate structure of organic forms, of cell function in physiology, and of the relation of life to its environment, and through the results of such a perfected knowledge finally in constant practice.

Men give drugs to each other simply for temporary relief and alleviation. The practice arose in ignorance and superstition, and is steeped in much of both in our own day. If disease has grown less frequent at all, I believe that the giving of drugs since time immemorial has had nothing whatever to do with accomplishing it.[2]

---

[1] *Man and Brute.* George J. Romanes in the *North American Review*, p. 145, August, 1884.

[2] That this begins to dawn upon the minds of honest physicians, see an interesting article by George T. Welch, M. D., in the *Medical Record* for June 14, 1884, entitled *Many Drugs, Few Remedies.* And to see the course surgery is taking, see *The Treatment of Wounds as Based on Evolutionary Laws*, by Mr. C. Pitfield Mitchell, member of the Royal College of Surgeons, London. This work is reviewed in the *Popular Science Monthly*, August, 1884.

In these days the connecting band between medicine and morphology is hourly becoming broader and more intimate, and the race which has descended from Hippocrates must, if they care to keep up with the general advance, seek the aid of their allies, the descendants of Democritus. This the thinkers in medicine have already fully availed themselves of, as their writings attest.

After all that I have said above, it will not be much of a surprise to my reader when he learns that I intend to have models and casts and skeletons of many of the "lower animals" in our museum of anatomy. Such will undoubtedly be the case; for not only will the anatomy of man's own class be fully exhibited in our museum, but I intend to cull from the *entire* range of organic nature all the essentials I please to exhibit there, in order to illustrate, as far as possible, a subject of which so much has been written, and in which such immense strides have been taken in the last quarter of a century—in other words, to show our modern conceptions of structure and the manner in which structure develops. It seems a marvel to me, sometimes, how little this subject is understood, even by persons who converse quite freely about the laws of evolution. Such people have generally obtained their scanty conversational knowledge second-hand. There are many others, I fear, in our time, who speak in contempt of the entire subject of biology, and, more particularly, of natural history, and of those that profess any interest in it. I have observed that such people, incompatible as it may seem, speak of medicine as almost a divine pursuit, and of the study of the human frame as all-important.

Another peculiarity of this class is, they are very fond of alluding to the study of comparative anatomy as an outside branch, and a very nice thing to have a taste for. Should chance ever throw a monograph on any particular animal except man in their way, a glance at the title usually elicits some such remark as, "Does he bite?" or "Is it good to eat?" and on receiving a reply in the negative to both these sage questions, the intelligent reviewer ceases to have any further interest in it.

> The small birds of summer seem to the Indian beneath his notice, and when asked the name, the answer not uncommonly is, "Why do you want to know its name? It isn't good to eat." They consider that when to a small winged animal they have given the name "bird," they have done their whole duty.[1]

The venerable American physiologist, Dalton, in speaking of the science to which he has contributed so much, says:

> But it cannot be made the exclusive subject of our study; for the special physiology of the human body cannot be properly understood without a previous acquaintance with the vital phenomena common to all animals and to all vegetables; besides which, there are many physiological questions that require for their solution experiments and observations, which can only be made upon the lower animals.[2]

[1] W. W. Cooke, *Bird Nomenclature of the Chippewa Indians.* In the *Auk*, vol. i, No. 3, July, 1884, p. 242. Boston.

[2] *A Treatise on Human Physiology,* designed for the use of students and practitioners of medicine, by John C. Dalton, M.D., page 34. Philadelphia, 1871.

The magnificent monument Flint has raised to the same science[1] breathes forth from every chapter the same conviction, and we all know with what telling effect he has put it in practice.

Students of human anatomy appreciate this as well as the physiologists, and truly is it said by one of the best of them that—"human anatomy is thus in itself a widely extended science, and stands in close relations to neighboring and allied sciences. Man is an animal, and his anatomy should be regarded as a natural history monograph. He is built on the same principles as his neighbors, and in most respects he is the best primary type for us to study for the purposes of comparative anatomy. As no one type, however, suits for the demonstration of all morphological laws, and as many of the principles of animal organization can be better understood and illustrated by the study of simpler forms, we require, therefore, to make frequent calls upon other animals to explain obscure points in human anatomy, and thus human anatomy is brought into close relations with comparative anatomy."[2] The most able and learned men of our day advance the same opinion. So we must not be surprised to find, in the words of an eminent anatomist, that—

> Man is an animal, and feels; in other words, forms one of a multitude of different kinds of organized and sentient beings, the bodies of which have obvious, but very various, relations with his body. It is clear, then, from the nature of the case, that man's body can only be comprehended by means of an extensive acquaintance with the bodies of other animals. Experience confirms this conclusion, as the exclusive study of man's body, though sufficient for the mere art of the surgeon, had led to quite erroneous estimates of the nature and meaning of parts of it; errors corrected only through the general science of organic forms; *i. e.*, the science of morphology.[3]

There is no doubt that many and many a human life has been sacrificed because the surgeon was ignorant of human anatomy at the time of his performing an operation. And it is very true, as the author whom I have just quoted says, that many of our erroneous notions of human anatomy are due to the fact that we are so ignorant of the anatomy of other vertebrates.

> The exhibition of each successive organ in all varieties and modifications discloses many aspects otherwise hidden, and places the more general and fundamental peculiarities in a strong light. Much of the insight that we at present possess regarding the brain is due to comparative anatomy. Too great pains cannot be given to the perfecting of the comparative method, and the grand secret is the lucid presentation of agreements and of differences.[4]

---

[1] *A Text-book of Human Physiology*, designed for the use of practitioners and students of medicine. By Austin Flint, jr., M.D. New York, 1876.

[2] Alexander Macalister, M.D., F.R.S., Professor of Anatomy, University of Cambridge. Introductory lecture, *On the Province of Anatomy*, published in the *British Medical Journal*, p. 808. London, October 27, 1883.

[3] St. George Mivart, F.R.S., etc. *Lessons in Elementary Anatomy*, p. 1. London, 1877. Professor Mivart is a member of the faculty of St. Mary's Hospital, and an author of several well known classical scientific works.

[4] Alexander Bain, LL.D., Professor of Logic in the University of Aberdeen. *Logic, Deductive and Inductive*, p. 539. New York, 1874.

Another thing that should never for a moment be lost sight of is this: our collection, not only as a whole, but as far as practicable in detail, should aim to illustrate by the things themselves, or the various ways of imitating them, the works and writings of every character of the teachers of the day. In no age has the vital importance, the great *practical* worth, and civilizing influence of the study of morphology been more universally appreciated than in the present. *It is the very back-stay of medicine, using this word to denote that science in its totality, and its refining influence cannot be overestimated.* Its teachers to-day are not few in number nor lacking in ability. If civilized peoples are in debt to any single man for his heroic efforts in his warfare against the ranks of those who are ignorant of such studies and deny their practical utility and their immense advantages, that man is Professor Huxley. In one of his excellent addresses upon this subject he remarks that—

> Biology needs no apologist when she demands a place—and a prominent place—in any scheme of education worthy of the name. Leave out the physiological sciences from your curriculum, and you launch the student into the world, undisciplined in that science whose subject-matter would best develop his powers of observation; ignorant of facts of the deepest importance for his own and others' welfare; blind to the richest sources of beauty in God's creation; and unprovided with that belief in a living law, and an order manifesting itself in and through endless change and variety, which might serve to check and moderate that phase of despair through which, if he take an earnest interest in social problems, he will assuredly sooner or later pass.[1]

The best and most advanced schools of medicine reiterate the same sentiment through their professors of anatomy and physiology,[2] and many an author who looks down upon me at this moment, through his works on my shelves, heralds the same truths.

The next consideration of the collection, as a whole, consists in presenting a concise review of organic nature as classified by modern biologists, or, in other words, of the mass of material at our disposal, upon which we are to draw for our illustrations in morphology and physiology. The almost infinite number of diversified forms now living upon the earth have descended from antecedent forms, through the enormous lapse of geological time, by infinitesimal and successive changes in obedience to certain laws. This is the main feature of the doctrine of evolution, in so far as organic forms are concerned. Everything within our ken seems to point to the fact that the starting point of all organic life was the protoplasmic *Monera*. This constant disposition to vary and

---

[1] T. H. Huxley. *On the Educational Value of the Natural History Sciences*, an address delivered at St. Martin's Hall, on the 22d of July, 1854.

[2] For excellent examples of this, see the able and valuable papers, (1) by Prof. Elliott Coues, on *The Nature of the Human Temporal Bone*, a lecture delivered in his regular course, from the chair of anatomy of the National Medical College at Washington (published in separate pamphlet), and (2) *The Rational Method of Teaching Anatomy*, by Frank Baker, M.D., Professor of Anatomy, University of Georgetown, D. C., published in the *Medical Record*, New York, April 19, 1884.

to change is still, and ever will be, in operation. It is one of the most universal and best established laws of nature. The operation of the change is (1) an impulse exerted on the part of each specific form from within, to be transmitted (heredity) and preserved, these same organisms likewise exhibiting a tendency to vary, due to certain internal conditions, and (2) an external impulse constantly exerted on the part of the conditions surrounding these forms to adapt them to themselves. Modification is further influenced by incessant competition for existence, and by the law of "natural selection," the general result being the annihilation or succumbing of the less adapted, and a survival of the winners. Almost hourly from all parts of the world facts are being brought to light that substantiate these laws. Paleontology takes a prominent place here, and the ever-increasing number of discoveries of the ancient forms that inhabited the earth is a source of the greatest interest and deepest importance. In these forms, of course, only the more or less perfect skeletons, as a rule, have been preserved as "fossils." From this enormous mass of material certain examples will be chosen to place in the collection of the museum, to illustrate the *transmission of structures* and the way in which it has been effected.

CLASSIFICATION OF THE FORMS OF THE ANIMAL KINGDOM.

Invertebrates.

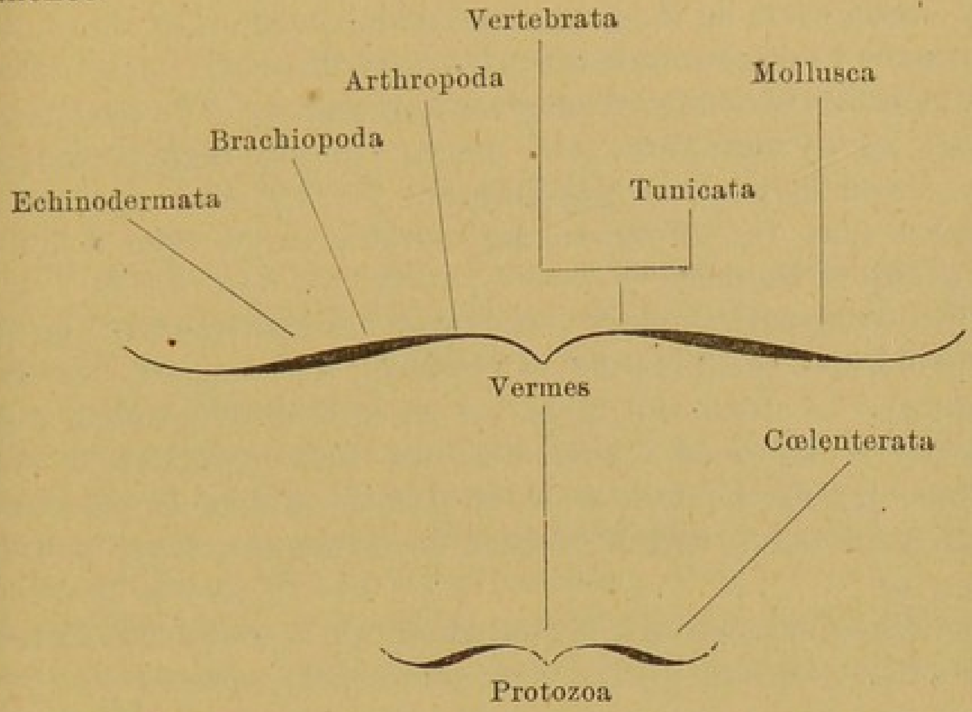
As we drop lower and lower in the scale of living organisms we approach, finally, and pass into that realm of minute and lowly forms so abundantly found in nature, from which both plants and the still more highly organized animals have sprung. Here we are brought face to face with groups of very numerous and chiefly microscopic series of forms, through which the latter-day zoologists have been totally unable to draw a hard and fast line dividing the animal from the vegetable types. Indeed, Professor Haeckel and his followers thought to obviate the difficulty by establishing a third primary division of the living world, to which the name of the *Protista* was given. The term *Protista* was to include all those forms supposed to be distinct from animals and plants. In my opinion this arrangement has by no means fulfilled its purpose, though it may answer very well until our knowledge of the subject is more complete.

For our purposes here, the old classification of these forms suits us best. It holds that one group, termed the *Protozoa*, shall include all of these low organisms that constitute the rootlets of the *animal* tree, while all those from which *plants* seem to spring we call the *Protophyta*.

With the numerous forms and structures that have arisen from the evolution of the *Protophyta* to constitute the vegetable kingdom, we shall have but little to do, and only to an extent that I will suggest further on.

Authorities differ somewhat in their *general grouping* of the enormous

array of animal forms now living upon this planet; for our present purposes I will present the following tree, and briefly characterize its branches.



This diagram shows approximately how these great groups of animals are genealogically related to each other, as well as their separations. The *Protozoa* include a number of forms, the simplest of which are composed of mere structureless protoplasm. A greater number possess a nucleus and nucleolus corresponding to the cell of all higher forms, the Protozoa never having but one of these in their organization, though some authors assert that the Protozoa which are classed as the shelled *Rhizopods* have more. *Amœba* and *Protamœba* are usually naked, but in some instances they also secrete a shell. The highest organized of all the Protozoa are the *Infusoria*. The literature pertaining to this primitive stock is very full, and intensely interesting.

The CŒLENTERATA include the sponges, the hydroids, the polyps, and the jelly-fishes. They constitute the first branch of the higher divisions of the Protozoa that are undoubtedly animals. Embryonically these forms, as a rule, separate into two cell-layers, the *ectoderm* and the *endoderm*. Here, too, we find an enteric cavity formed by a pit sunken in the body, and in some forms the first steps toward a specialization of a digestive system. The *Cœlenterata* fall into two divisions,—the *Spongiæ* and the *Acalephæ*, each including several groups and many forms.

In VERMES (worms) we have an enormous collection of forms, divided into many groups. They are in general characterized as having a head and tail end; a dorsal and ventral aspect; the highest having segmented bodies, a digestive tract, and rudimentary nervous system and circulatory apparatus. In organization they are many-celled and possess three layers in the germ stage.

Naturally this great division of the animal kingdom has received much

attention from zoologists and authors. The authorities hold somewhat varying views upon its classifications and subdivisions. It must be borne in mind, however, that the types of this division are deserving of the closest study, as from it sprung the other divisions of the animal world, above the Cœlenterata and Protozoa, while its relations and connections with other branches are of great importance. The tendency to become more highly specialized and merge into the higher groups is beautifully shown in many of the Vermes. In fact some authors are of the opinion that the Mollusca are nothing more than a highly-organized group of Vermes.

The ECHINODERMATA include the star-fishes (*Asteroidea*), the sea-urchins (*Echinoidea*), the lily-stars (*Crinoidea*), and the sea-cucumbers (*Holothuroidea*). In them the digestive tract is differentiated and a perienteric cavity is formed. A tendency in their organization to assume a radiate arrangement, more or less defined in some forms, is seen. They are marine animals, with a calcified integumentary layer inclosing the body cavity.

The BRACHIOPODA constitute a limited but quite well-defined group. In earlier geologic times they were very numerously represented. They are distinguished at the present time as having a bivalve shell, the two halves being movable upon each other; the lobes of the pallium; and certain specializations from Vermes in the nervous and digestive systems, of a character sufficiently well-marked to justify us in assigning them to a group by themselves.

The ARTHROPODA include two groups of very interesting animals, representing many forms. These are the Crustaceans and Insects. The principal characters are seen to be, a segmented body; the possession of segmented legs arranged in pairs; the presence of jaws, antennæ, palpi, and maxillæ; the greater or less symmetry of the two lateral halves of the body; and, finally, the integuments represented by a hardened case, as in a lobster or beetle.

The *Crustacea* include many well-known forms, such as crabs, cray-fish, lobsters, shrimps, and water-fleas.

The *Insecta* are also familiar to us in the many forms of winged insects, mites, centipedes, and spiders.

The MOLLUSCA, forming as they do another general division, are represented by such animals as the mussels, clams, snails, certain creatures living in the many forms of shells, and the nautilus. Many species occur in the fossil state, and the law of evolution is exemplified with wonderful clearness in some of the transitional stages. In the Mollusca, as a rule, the central nervous system is above the digestive tract, from which branches are given off to the ganglia beneath it; the dorsal position of the heart, and the commissures surrounding the pharynx, are also excellent characters, taken in connection with others, for differentiation.

The TUNICATA long puzzled systematic zoologists, and various views were entertained as to the position they should be awarded in the sys-

tem. At one time they were placed among the Mollusca, but now I believe the opinion is quite general that they should be awarded a separate division. The Ascidians are the principal forms of tunicates—marine animals quite common in many parts of the world. They possess certain striking affinities with the Vertebrata, of so much importance that I will treat this division more in detail when the collection is taken up in discussion.

Vertebrates.

The VERTEBRATA are distinguished from the other groups or divisions by the possession of a skeleton which lies in the line of the long axis of the body, and the division of the latter into a number of primitive vertebræ (*Metameres*).

The construction of the axial skeleton is of such a nature that it divides the body into two longitudinal cavities. Of these the dorsal one contains the central nervous system, while the ventral one harbors the circulatory apparatus and digestive tract.

The segmentation of the axial skeleton in this group differentiates it from the tunicates (*Tunicata*), and still more from all invertebrated animals.

In my endeavors to present to the mind of my reader an idea of the groups into which the Vertebrata have been divided, I can do no better than avail myself of the very admirable tables constructed by Professor Haeckel.[1]

There is no group of animals of nearly so much importance to us as the one we are about to discuss. To it man himself belongs, and from it we have derived, and are still deriving every day, facts that elucidate matters of the greatest possible importance in his structure. All those groups that I have briefly defined previous to the VERTEBRATA are designated by zoologists as the INVERTEBRATA. They include the marvelous variety of forms all the way from the Protozoa through the Tunicata, as outlined in their definitions above.

The following table, the first presented us by Professor Haeckel in his division of the Vertebrata, is an exceedingly important and convenient one, stripped as it is of all superseded notions, and logically based upon our present and advanced knowledge of the subject:

A. Skull-less animals. ACRANIA.			1. Tubular hearts.	1. Leptocardia.
B. Animals with skulls (CRANIOTA), or thick hearts (PACHYCARDIA).	*a.* Single-nostriled animals. *Monorrhina.*		2. Round-mouths.	2. Cyclostoma.
	b. Double nostriled animals. *Amphirrhina.*	I. Non-amnionate. Anamnia.	3. Fish.	3. Pisces.
			4. Mud-fish.	4. Dipneusta.
			5. Sea-dragons.	5. Halisauria.
			6. Batrachians.	6. Amphibia.
		II. Amnionate. Amniota.	7. Reptiles.	7. Reptilia.
			8. Birds.	8. Aves.
			9. Mammals.	9. Mammalia.

[1] The *History of Creation*, by Ernst Haeckel. Translated by Prof. E. Ray Lankester from the German. American edition, vol. ii, p. 198, *et seq.* 1880.

This comprehensive arrangement splits the Vertebrata into nine main *Classes*, a division based upon very strongly marked structural characters, though these classes must not be understood as having the same genealogical value.

The first group, A—the ACRANIA—contains only the first class, the *Leptocardia*. This class is represented by one form only, the famous lancelet (*Amphioxus lanceolatus*). Every student of physiology knows of it as the lowest organized vertebrate of which we have any knowledge. It lacks a head, and consequently is without skull or brain. The heart is non-centralized and tubular. The most important feature in the economy of *Amphioxus*, however, is that in common with other vertebrates it is in possession of a *chorda dorsalis* and *medulla spinalis*. Moreover, what is still more remarkable and important, in certain other parts of its organization it seems to be comparable with the invertebrate tunicates (Ascidians), and so links the Vertebrata and Invertebrata. The lancelet is still found in many parts of the world and on our own Atlantic coast, being everywhere a marine animal. In past times it must have had many relations with other forms and have been represented by kindred types; but these have all perished, their soft bodies never petrifying to form fossil remains.

The second main division in our table, B, is composed of the remainder of the vertebrate kingdom. In them a skull is always present and they have thick-walled hearts. They may be primarily divided into *a* and *b*, as shown, or such animals as have but a single nasal tube and those wherein it is double.

The *Monorrhina* include the entire second class (*Cyclostoma*), one of great importance, as in it we find animals that were undoubtedly developed from the *Acrania*. In it belong the hags and lampreys, marine and river forms, to which I shall have occasion to refer again.

The second division, *b*, may be subdivided into animals that are without an amnion in the embryo, and those where this membrane is present. This gives us the ANAMNIA and the AMNIOTA.

The non-amnionate group includes the third, fourth, fifth, and sixth classes, while the last three classes, or the seventh, eighth, and ninth, are under the amnionate division.

I will present one other table from the "History of Creation," drawn up by Professor Haeckel, and also, later, this eminent philosopher's Pedigree of Vertebrates. The tabular history, which is given first, presents a systematic survey of the four main classes, nine classes, and twenty-six subclasses of the Vertebrata. To carry the division further than the subclass in the present connection, or into orders and suborders and families and genera, is not to be entertained for a moment. It would not only occupy far more space than could be possibly allowed in an article of this kind, but would to the lay reader be more or less confusing. I will feel myself at liberty, however, where it becomes necessary, to enlarge upon any special subclass or class, as no doubt it

will be in the case of the Mammalia. In explanation of the divisions beyond the subclass, I will insert, first, a tabular illustration of a sequence of zoological groups, from highest to lowest, under which a bird may fall; this I select from Prof. Elliott Coues's "Key to North American Birds," page 81 of the last edition.

Kingdom, *Animalia:* Animals.
Branch, *Vertebrata:* Back-boned animals.
Province, *Sauropsida:* Lizard-like Vertebrates.
Class, *Aves:* Birds.
Subclass, *Carinatæ:* Birds with keeled breast bone.
Order, *Passeres:* Perching birds.
Suborder, *Oscines:* Singing birds.
Family, *Turdidæ:* Thrush-like birds.
Subfamily, *Turdinæ:* True thrushes.
Genus, *Turdus:* Typical thrushes.
Subgenus, *Hylocichla:* Wood thrushes.
Species, *ustulatus:* Olive-backed thrush.
Subspecies, *aliciæ:* Alice's thrush.

The following table is the one alluded to above, taken from Prof. Haeckel's work (vol. ii, p. 204):

SYSTEMATIC SURVEY OF THE FOUR MAIN CLASSES, NINE CLASSES, AND TWENTY-SIX SUBCLASSES OF VERTEBRATA.

I. Skull-less (*Acrania*), or tube-hearted (*Leptocardia*). Vertebrata without head, without skull and brain, without centralized heart.

1. Skull-less, *Acrania.*	I. Tube-hearted, *Leptocardia.*	1. Lancelet.	1. Amphioxus.

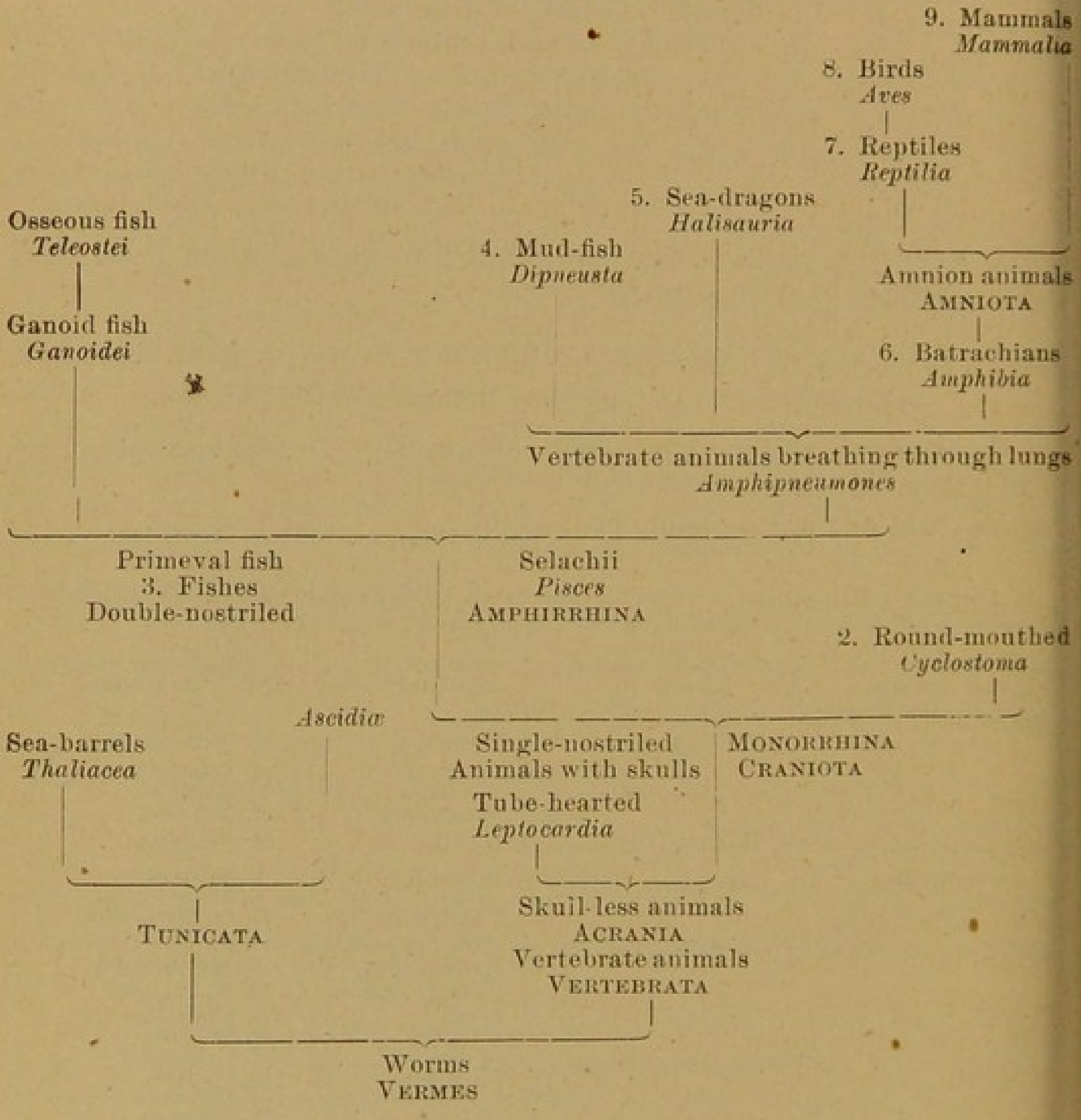
II. Animals with skulls (*Craniota*), and with thick-walled hearts (*Pachycardia*). Vertebrata with head, with skull and brain, with centralized heart.

Main classes of the skulled animals.	*Classes of the skulled animals.*	*Subclasses of the skulled animals.*	*Systematic name of the subclass.*
2. Single-nostriled, *Monorrhina.*	II. Round-mouths, *Cyclostoma.*	2. Hags.	2. Hyperotreta.
		3. Lampreys.	3. Hyperoartia.
3. Non-amnionate, *Anamnionata.*	III. Fish, *Pisces.*	4. Primeval fish.	4. Selachii.
		5. Ganoid fish.	5. Ganoides.
		6. Osseous fish.	6. Teleostei.
	IV. Mud-fish, *Dipneusta.*	7. Mud-fish.	7. Protopteri.
	V. Sea-dragons, *Halisauri.*	8. Primeval dragons.	8. Simosauria.
		9. Snake-dragons.	9. Plesiosauria.
		10. Fish-dragons.	10. Ichthyosauria.
	VI. Batrachians, *Amphibia.*	11. Mailed batrachians.	11. Phractamphibia.
		12. Naked batrachians.	12. Lissamphibia.
4. Amnionate animals, *Amnionata.*	VII. Reptiles, *Reptilia.*	13. Primary reptiles.	13. Tocosauria.
		14. Lizards.	14. Lacertilia.
		15. Serpents.	15. Ophidia.
		16. Crocodiles.	16. Crocodilia.
		17. Tortoises.	17. Chelonia.
		18. Flying reptiles.	18. Pterosauria.
		19. Dragons.	19. Dinosauria.
		20. Beaked reptiles.	20. Anomodontia.
	VIII. Birds, *Aves.*	21. Long-tailed.[1]	21. Saururæ.
		22. Fan-tailed.	22. Carinatæ.
		23. Bush-tailed.	23. Ratitæ.
	IX. Mammals, *Mammalia.*	24. Cloacal animals.	24. Monotrema.
		25. Pouched animals.	25. Marsupialia.
		26. Placental animals.	26. Placentialia.

[1] The writer is of the opinion that the *Archæopteryx* possessed quite as many reptilian characters in its organization as it did avian ones, and in fact held a mid position between these two groups. (See my article in the *Century* for January, 1886, pp. 352–364. Published by the Century Company, New York City.)

What I said above in regard to carrying the groups beyond the division of subclass applies also, of course, to the scheme of the Pedigrees. The one I present shows the development of the *nine classes*, just given in the "Systematic survey," in a very comprehensive way, and is extended far enough for our purposes in the present connection. Professor Haeckel, in his work, has, with great care and skill, carried these nine classes out very much further, using similar methods. As, for instance, Class IX, Mammalia, is not only brought up to man, but through the species of men, in some cases.

PEDIGREE OF VERTEBRATES.



We have already briefly alluded to the *Amphioxus* and its relations, and had something to say about the second main class, the *Monorrhina*. It now remains, in order to complete our general, though condensed survey of the Vertebrata, to pay an equal amount of attention to the remaining seven classes. The reader will be very much assisted in this by occasionally refreshing his memory through the use of the above tables and the tree showing their pedigree.

We find the class *Pisces* divided into three very distinct subclasses, to wit: the primeval fish (*Elasmobranchii*); the ganoid fish (*Ganoidei*); and the osseous fish (*Teleostei*).[1] In geologic times the Devonian seas swarmed with fish, long since extinct. The best representatives of these forms now living are the sharks and rays, with the unique Holocephali (*Chimæra*). They are known to ichthyologists as the Selachians, and are the forms referred to as the Primeval fish. Their skeletons are cartilaginous, but their teeth, quite like these organs in other fishes, are hard like enamel, and so have been preserved in the earth's crust. There is much in their development and structure deserving of the closest study, and the anatomists have by no means slighted it.

A very important subclass are the *Ganoidei*. These fishes derive their name from the elegant enameled plates that cover the bodies of the majority of the forms. Ganoids also occurred very abundantly everywhere during the Devonian age. Their teeth in many cases were of a reptilian character. The ganoids are now nearly an extinct race, and only a few living forms still remain, such as our American mud-fish (*Amia calva*), the sturgeons, the gar-pikes of American rivers, and polypterus of the Nile, ceratodus of Australia, and the lepidosiren of Africa, with a few others. These strange fish, if anything can be strange in nature, stand midway between true fishes and amphibians. Several of the types breathe by means of lungs, while a recently discovered Australian specimen, *Ceratodus Fosteri*, only resorts to the water in winter, and during the summer lives in a nest it constructs on the land in the mud. Wilder, through careful experiment, ascertained that our mud-fish (*Amia*) had to rise to the surface to breathe.

The anatomy of the ganoids is full of interest and significance. Some of the forms I will refer to again when speaking of certain specimens for the collection.

In the *Teleostei* we "come to a type of fishes which, within very recent geological times, as well as during the present period, has become differentiated or broken up into thousands of species, corresponding to the complexity of their physical environment, as compared with the simple features of the physical geography of Devonian and Carboniferous land masses. Like most of the larger groups of animals, as the decapod Crustacea, and especially the insects, as well as the mollusks, the bony fishes have attained an astonishing amount of specialization, as if the tree of ichthyic life, taking root in the Silurian age, and send-

[1] It must be observed that in this arrangement I disagree with Professor Haeckel in his awarding the mud-fish a distinct class, but agree with other authors in retaining them among the ganoids. Huxley, in his paper on *The Genealogy of Animals*, in which he reviewed Haeckel's classification, says: "But considering the close relation of the mud-fish with the *Ganoidei*, and the wide difference between the *Elasmobranchii* and the *Teleostei*, I greatly doubt the propriety of separating the *Dipneusta* as a class from the other *Pisces*." (A Review of Haeckel's *Natürliche Schöpfungs-Geschichte*. The *Academy*, 1869.)

ing out but a few branches in later Palæozoic times, had suddenly, in the Cretaceous and Tertiary ages, thrown out a multitude of fine branches and twigs, intertwining and spreading out in a way most baffling to the systematist. The essential diagnostic characters of the bony fishes, *i. e.*, such as separate them from the elasmobranchs and ganoids, are as follows: The skeleton is bony, the vertebræ being separate; the outer elements of the scapular arch are simple, the inner elements for the most part bony and usually three or two in number; the pectoral fins are without any bone representing the humerus, and are connected with the scapular arch by several (generally four) narrow bones (Gill). The optic nerves cross one another. The gills are free, usually four on each side, and with several opercular bones. The heart is without a cone, but with an arterial bulb, and with but two valves at the origin of the aorta. The intestine is destitute of a spiral valve."[1]

The *Halisauri*, composing Class V, were huge reptiles of prey that have been extinct for ages; of their fossil remains, however, we have many and excellently preserved examples. They were the tyrants of the air, sea, and land during the times they flourished. From the fact that the skeleton of their limbs is constructed on the paddle plan of many bony rays, we are enabled to say that they branched off from the main vertebrate stock before the Amphibia did, as these latter, in common with all the higher vertebrates, are stamped with the pentadactyl foot, thus conclusively pointing to one origin. Haeckel seems to think that they, "in conjunction with the *Dipneusta*, branched off from the *Selachii*, but did not develop into higher Vertebrata; they form an extinct lateral line of the pedigree, which has died out."

We shall have to allude to the reptiles of this geological horizon again, in another connection.

The mailed Batrachia of Class VI (*Amphibia*) also represent a legion of huge forms that disappeared near the end of the Triassic period. They are offshoots from frog-like and crocodilian types, though they grew to far larger sizes, and were really very formidable monsters. As their name indicates, their chief characteristic was that they wore a heavy coat of mailed armor. In present times certain blind snakes seem to be their only descendants (*Cæciliæ*). These have an external smooth skin, with scales embedded in it (*Cæcilia compressa cauda*). The naked Batrachia, forming as they do the second subclass of the Amphibia, were also represented in past ages by many primordial forms. These were brought down as far as the Tertiary epoch, where a few of their fossil remains are to be found. They differ from the mailed Batrachia in having a smooth, slimy, and naked skin, devoid of all scales or plates.

Living types are seen in sirens (*Trachystomata*), necturus (*Proteida*), salamanders (*Urodela*), and frogs and toads (*Anura*).

[1] A. S. Packard, jr., M.D., Ph.D. *Zoology*, second edition, revised, p. 434. New York, 1880.

The historical development of the entire subclass is repeated in the ontogeny of any of these living orders. This matter will again be spoken of when I come to discuss certain forms of salamanders for the collection.

From the Amphibia we pass to the still more important groups of amnionate animals, or the reptiles, birds, and mammals. In these classes many new structures and changes make their appearance for the first time in ascending the scale. Not only is an amnion present in fœtal life, a fact already alluded to, but throughout their entire existence these classes have always respired by the means of lungs, gill-structures having been totally lost. Important changes have been brought about in the skeletons, in the essential parts of the organs of sense, and the lachrymal glands first appear. One ponders with amazement as he reads accounts of, or is brought face to face with, the remains of extinct forms, or the multiplicity of still living forms that comprise these classes. To me, nothing is so full of absorbing interest, there is nothing I delight to dwell upon more. We picture the Amphibia slowly evolving from the lung-fishes far back in palæolithic time, and in their stock in turn we see the root of all other Vertebrata. After still further development another split takes place, and we have two more branches, Mammalia being the one, the other common to Reptilia and Aves.

During these changes and the varied warfare for existence, the geological horizons have been thickly strewn with thousands upon thousands of the most extraordinary creatures, of all sorts and sizes. They have presented every imaginable degree of relationship with each other: bird-like reptiles, reptile-like birds, bird-like mammals, mammal-like reptiles, and so on through the series.

So far as the reptiles are concerned, but four orders exist in our time; these are the lizards, serpents, crocodiles, and tortoises. A miserable remnant of the host of their many and wonderfully formed ancestors! The vast number of remains now known to us is being added to every day; indeed, but a few years ago, Professor Marsh brought to light the subclass *Odontornithes*, or birds with teeth, several forms of which are the direct connecting links between ancient reptiles and our modern class of birds. In these days, when such things are far more generally read, I am glad to say, we are all familiar with the ancient *Archæopteryx* of the Jurassic, bearing its long, jointed tail, adorned with forty-two feathers, or a pair to each joint, a wonderful form, standing between birds and reptiles. No less interesting was *Compsognathus*, a bird-like reptile, that habitually moved about upon its hind legs only; but it is impossible for us to enter, even by name of the animals, further upon such an extensive subject here.

Existing birds, then, fall into the two following orders: the *Ratitæ* and the *Carinatæ*. The former are struthious birds, like the ostrich and apteryx, with a keelless sternum and rudimentary wings; the latter,

making up as they do the vast majority of living birds, possess well-developed wings and a keeled sternum. Extinct ancestors of birds are also awarded two orders, the *Saururæ*, which contains the *Archæopteryx*, and the *Odontornithes*, already mentioned, which contains the toothed birds discovered by Marsh in the cretaceous beds of Kansas.

As with birds, so it is with mammals; in all parts of the world the fossil remains of their progenitors are to be found. New forms come to light every day, some simple, some wonderfully complex, but all easily accounted for when submitted to the doctrine of descent. One of the best examples of this is the series of animal remains from several geological horizons, showing the origin of the horse. This illustration is familiar to all who have read Professor Huxley's description of it, or indeed any good modern work upon geology.[1]

Speaking of the classification of living Mammalia, a very eminent zoologist says:

> A perfect arrangement of any group of animals can only be attained simultaneously with a perfect knowledge of their structure and life history. We are still so far from this that any classification now advanced must be regarded as provisional, and merely representing our present state of knowledge. Moreover, as naturalists will estimate differently the importance to be attached to different structural modifications as indicative of affinity, it must be long before there will be any general agreement upon this subject.[2]

The classification most generally adopted is the one originally proposed by De Blainville, which divides all living Mammalia into three groups. These three groups are (1) MONODELPHIA, (2) DIDELPHIA, and (3) ORNITHODELPHIA. The last subclass mentioned, the *Ornithodelphia*, contains but the single order of the *Monotremes*, or the Monotremata. This order includes but two living forms, the well-known duck-bill (*Ornithorhynchus*) and the spiny ant-eater (*Echidna hystrix*). These very interesting animals are confined to the Australian continent, the off-lying island of Tasmania, and two forms of *Echidna* in New Guinea. Morphologically they are distinguished by the following characters: there is a large cloaca (vent), common to the rectum and the urinary and genital organs, as seen in birds; and in common with these and also with the Amphibia we find the large beak-shaped processes of the shoulder-blades articulating with the breast-bone. A T-shaped interclavicle also exists, differentiating them from all other mammals. They have no true teeth, but horny bills, like birds, and the very imperfect young, when they are born, have a nib in the end of this bill, as we see in chickens and other fowls. Indeed, nearly all their characters, forming too long a list to mention in full here, link them with reptiles, birds, and the Amphibia, or really

[1] See Joseph Le Conte, *Elements of Geology*, p. 533. New York, 1883. Also *Lectures on Evolution*, by Thomas H. Huxley. Published in the Humboldt Library, No. 36, vol. ii. New York, September, 1882.

[2] William Henry Flower, F.R.S., etc. *An Introduction to the Osteology of the Mammalia*, page 1. London, 1876.

with the lower Vertebrata. Quite recently it has been discovered that *Echidna hystrix* lays eggs, from which its young are subsequently brought forth. Nothing could show better than this the former affinity existing between reptiles and mammals.

The subclass *Didelphia* includes the marsupials, animals of a very low grade of intelligence, though structurally higher than the monotremes. They are all confined to New Zealand, New Guinea, and Australia, with the exception of the opossums. Australia claims by far the major share of the group. When their young are first born they are introduced into an abdominal pouch of the female, called the marsupium. This is supported by a special pair of bones, if such be their function, that articulate with the pelvis. The young long remain attached to nipples at the base of this pouch, even until they attain some little size and are strong enough to jump in and out unaided by the mother. There are marsupial bears, rats, squirrels, and ant-eaters; the best-known forms, however, are the kangaroos and opossums.

All other living mammals are included in the last and most important subclass of all,—the *Monodelphia*. This class includes man himself, as well as the lower Vertebrata which most resemble him. In point of structure, the transitional gaps between these higher mammals and the cloacal forms are filled by the marsupials. This is particularly true in the anatomical structures of the reproductive organs. The highly specialized *Monodelphia*, now under our consideration, all develop a *placenta* during gestation. The brain also possesses a *corpus callosum* and many other evidences of morphological advance over the lower forms.

I here present a table showing the orders into which the monodelphian mammals are grouped:

Order.	Examples.	Remarks.
1. Edentata	Armadillos, sloths, ant-eaters, and pangolins	All animals of low organization.
2. Rodentia	Hares, beavers, squirrels, rats, porcupines, etc	Well-defined group.
3. Proboscidea	Elephants	Two species.
4. Hyracoidea	Hyrax	The only genus.
5. Ungulata	Hoofed animals, divided into— (A) *Perissodactyla*, *e. g.*, horse, tapir, rhinoceros, or the odd-toed ungulates. (B) *Artiodactyla*, *e. g.*, the even-toed ungulates: (*a*) Non-ruminants, *e. g.*, pig, hippopotamus. (*b*) Chevrotains, *e. g.*, musk-deer. (*c*) Tylopoda, *e. g.*, camel, llama. (*d*) Ruminants, *e. g*, deer, sheep, cow.	
6. Sirenia	Dugongs, manatees	Aquatic herbivora.
7. Cetacea	(A) *Mystacoceti*, *e. g.*, Whalebone whale. (B) *Odontoceti*, *e. g.*, Cachalot, dolphin, etc.	
8. Carnivora	(A) *Fissipedia*, *e. g.*, cat, dog, bear. (B) *Pinnipedia*, *e. g.*, seal, walrus, etc.	
9. Insectivora	Hedgehogs, moles.	
10. Cheiroptera	The bats.	
11. Lemuridæ	The lemurs	Including the families *tarsiidæ* and *chiero-myidæ*.[1]
12. Primates	Various species of men, apes, and monkeys.	

[1] It will be seen from this arrangement that I consider the lemurs a very much inferior group, though structurally they connect the primates with the bats, carnivora and insectivora.

This table completes my brief sketch of the animal kingdom, at best but a mere hint at the classification of the myriad living animal forms that inhabit our earth to-day. To gain some idea of this number we should remember that it is estimated that at least 192,000 species of insects have been described, 2,200 of mammals, and 11,000 of birds, to say nothing of the lower forms.

Now, it may be asked, Who is expected to have a knowledge of all this? Of the detailed structure of the vast majority of these animals we know as yet but very little. Many of the forms, however—man the most extensively—have been fairly described, so far as their anatomy goes, and the great underlying principles of the structure of the groups are pretty well known.

There are men born by nature to prosecute such studies for the world's good. For I believe "From time to time God raises up individuals, cast in a special mold, and set apart for a special destiny, vowed to a special work; men whose entire power, thought, sensibilities, seem to lie in the channel of their appointed calling, whose mission is their joy,[1] the fiery energy of whose purpose burns up every other longing, the magnitude of whose glorious aim dwarfs and smothers every other object."[2]

All I expect is that the general collection, soon to be discussed, shall set before the public and the professions—that of medicine in particular—in a clear and comprehensive way, all those gradations and principles in morphology of which every intelligent man ought at least to have a very fair knowledge at this day. Indeed, I deem it as a lacking in a liberal education, where entire ignorance of such matters actually exists.

APPENDAGES TO A MUSEUM; METHODS OF EXHIBITING ANATOMICAL SUBJECTS.

Now to return to the subject of the museum; in the remaining department, already alluded to, there should be all the material so necessary for the use of the special student and investigator. Here should be found a collection, as complete as possible, of the *disarticulated skeletons* of animals. These come to little more than their original cost, and in many instances are donated. They should be properly stored in

[1] Yet there are some to whom a strength is given,
A will, a self-constraining energy,
A faith that feeds upon no earthly hope,
Which never thinks of victory, combating
Because it ought to combat, * * *
And, conscious that to find in martyrdom,
The stamp and signet of most perfect life,
Is all the science that mankind can reach,
Rejoicing fights and still rejoicing falls.
—*The Combat of Life*, Richard Monckton Milnes (Lord Houghton).

[2] W. R. Greg. *Enigmas of Life*, pages 218 and 219. Boston, 1874.

cases of drawers with tablets on the outside giving briefly the particulars in regard to the specimens. Cases and drawers of this kind can be arranged on the same plans of classification as the specimens are themselves. A catalogue should exist giving *all* the necessary information in regard to the material in this division, and some person should be appointed to take charge of all the affairs pertaining to it. Finally, it is here that workers in any special branch really should find *all the material necessary for comparison*, and those contrivances so well known to us in our biological investigations. No casual visitor, under any consideration, should be allowed access to this place.

There are quite a number of ways of illustrating and placing upon exhibition anatomical subjects. The special method employed depends, of course, upon the character of the subject and the nature of the information that it is intended to convey to the mind of the examiner or visitor. Skeletons are exhibited principally in two ways,—the natural object itself, or else a cast of it made by some one of the many processes now in vogue. They may likewise be shown on charts and drawings. In any case they should be *perfect* in every respect, properly prepared, with no bones missing, and none mounted in the wrong place. In our day there are many excellent ways of cleaning and artistically mounting skeletons. The simplest way, however, is always the best, *i. e.*, the skeleton exhibited without brass fastenings, as far as possible, and free from all toy-makers' devices. Particular care should be taken with all the articulations, and they are most instructive when gotten up as an *honest* preparation, well-mounted, in normal posture, upon a plain black-walnut stand.

Casts, models, papier-mâché preparations, and all such methods, are of great value. The French are making casts now in a preparation of wax and glycerine that takes most perfect impressions, and also most wonderful imitations of anatomical subjects in many other kinds of material.

I am of the opinion that injected and dried dissections are of little value, and in most cases of none whatever, when the labor and expense incurred in their preparation are taken into account. Moreover, even when prepared at their best, they teach but little and are always ghastly and disagreeable objects.

Soft parts are best preserved in 85 per cent. alcohol; they should be properly suspended from glass rods in glass jars of suitable size and shape. Histological specimens, illustrating *all the tissues in a comparative way*, are nowadays beautifully magnified to a proper size and photographed on glass slides, and exhibited in a very convenient instrument constructed for that purpose. These slides should compare, in consecutive series, such subjects as the blood corpuscles, bone, muscular, nervous, and other tissues of the Vertebrata, as well as all manner of cells and appendages of the skin, and also sections of the organs or parts of them.

Another exceedingly important method of illustration is by means of photographs, charts, or other drawings. These are to be of two kinds, one sort to be suspended in proper places, either against the walls, or else inside the cases, so as to form the background for the other articles shown therein; the other kind of drawings or illustrations is best displayed by inclosing them in glass in frames, hung by hinges to upright pillars or supports, after the fashion used to illustrate the botanical specimens in the U. S. National Museum in Washington. One of these devices consists of an upright, central wooden pillar, to which are movably suspended, like the leaves of a book, the frames containing the drawings. These latter are shown upon both sides of the "leaves," as it were, and are covered with glass, the frames being made of the same handsome wood as the central pillar or standard. When closed and placed against the wall these frames take but little space, and when examined, leaf by leaf, offer a wonderful amount of surface for illustration in a very convenient way, the whole apparatus being about six feet high. For the sake of brevity I shall designate these contrivances throughout my article as "folders", when there is occasion to allude to them.

When the collection in a museum of anatomy is properly kept, and all the specimens properly prepared, no disinfectants are required. Nothing can be more disgusting in such a place than to see displayed, in all the cases, pots and jars containing camphor or benzine, both giving off suggestive odors. They are almost as bad as dust and cobwebs. *Dermestes* and other museum pests never appear where there is nothing for them to feast upon, and in a case of skeletons there never should be anything suitable for their consumption.

Another matter of high import in a collection of this kind is to have it properly labeled. The labels should consist of two kinds,—a simple "label" and a "tablet." The simple label is intended for such specimens as do not require any particular description; for instance, a skull of a beaver in a series of skulls of the Rodentia, arranged to compare their characters.

Such a label would read like this:

AMERICAN MUSEUM OF ANATOMY, No. 96.

Castor fiber.

Beaver.

Donor: *Dr. T. N. Hamilton.*

Collector: *James Fitzroy, Esq.*

Locality; Date: *Oregon*, 1873.

The tablets will be far more elaborate and should be introduced wherever necessary. They are intended to present in a clear and concise way what the specimen teaches and is really intended to show. Such

a tablet would also be applicable to *the case* containing the skulls of the Rodentia just cited. Take another example, however, say like this:

AMERICAN MUSEUM OF ANATOMY, No. 208.

Pectoral limbs of a Bat (A); *Archæopteryx* (B); *Hawk* (Buteo) (C); *and Pterodactyl* (D).

Donor, *W. A. Mackenzie, Esq.*

Prepared and purchased in Paris, 1883.

These specimens are designed to show the existing differences among various forms in which the arm, fore-arm, and hand have been modified for flight. A is a bat (*Pteropus*), an example of an existing flying *mammal*. The fingers support the membranous web between them in life. Notice the reduction of ulna. In B the three fingers of the extinct *Archæopteryx are free* (in the fossil). This form, of which there are but two specimens in existence, is one connecting birds and reptiles, and is from the Jurassic epoch. Its wings supported perfect feathers, and its structure shows it to be a transition from one class to the other of the two just mentioned. C, a hawk, an existing bird, has only the *thumb* free, other digits anchylosed together as in modern birds. In the extinct *Pterodactyl* we have an animal with both reptilian and bird characters, with the membranous wings of a bat. In the bat but one finger is *free* and *clawed*, while the others support the web. In *Pterodactyl* one finger was enormously enlarged and strengthened to support the web, while the others were all free and clawed.

Labels should be carefully printed in black ink, Roman type, on a rather pale, dun-colored ground, as the cards are then less likely to show dust or accidental marks.

In institutions where it is practicable, it is a very valuable acquisition to have connected with the museum a gallery devoted to the uses of a photographer, an artist, and a printer with a small printing press. Three such experts could be well employed in a museum of anatomy, especially during its entire formative stages, and no doubt to advantage always. It is a far more economical method of having things done, to say nothing of having them properly done, than it is to employ outside helpers. In these times it would not be difficult to find all these qualities combined in one man, and such a person could form one of the permanent employés of the institution. The art of photography is now easily acquired, and many photographers are fair copyists and colorists, so that it would require but little experience to enable them to print the labels and execute the other work required.

DETAILS OF THE COLLECTION.

(1) *Acrania.*

We will now devote our attention to the collection itself. This must illustrate, though far more in detail, the outline of living nature which I have attempted to present.

So far as the lower forms of animal and plant life are concerned, it will only be necessary to illustrate them by a sufficient number of the

large glass slides spoken of above and two or three "folders." These all should be fully *tabulated*, giving a concise description of the forms presented, their nature and significance. Enlarged drawings of the simplest Protozoa should be given, showing the method in which they throw out their temporary *pseudopodia*. A very good example of a Moner is seen in Haeckel's *Protomyxa aurantiaca*, and his plate with an abbreviated description might be copied with great advantage. An *Amœba* with its nucleus, etc., should also be shown, as well as good examples of *Myxomycetes*, *Diatomaceæ*, and *Labyrinthulæ;* also those minute forms generally regarded as the lowest of the animal world, as *Rhizopoda*, *Noctilucæ*, *Protoplasta*, and *Flagellata*. One entire "folder" should be given to illustrating a few *Fungi* and *Algæ*, then a few plants well up in the scale, and finally the anatomy of a typical plant with flowers. But here we let the vegetable world drop. A good plant to choose and an excellent description to illustrate would be the Bean Plant (*Vicia faba*), the parts of which have been so carefully and concisely described by Huxley and Martin.[1]

Now in the same manner the entire invertebrate kingdom, as I have sketched it out, should be illustrated by large colored drawings in these "folders"; two or three classes could be gotten into each one. The descriptions should be in large, readable type, and the drawings very carefully and accurately executed. The chief object is to show how the forms pass from the simple to the more complex, and their classification and position in the system. When we arrive at Insecta and Crustacea, however, it would be as well to devote one case to two large papier-mâché models, one representing a cray-fish and the other a typical beetle. These should have their various parts thoroughly thrown apart and named, each name to be in good-sized type, printed on a white slip of paper, and pasted in proper position. A good example as to the way this should be done can be seen in the specimen of *Caloptenus spretus* in Packard's Zoology, Figure 278 on page 329. An excellent background for this model, in colors, would be enlarged drawings of other details of structure from the same work (Figs. 279, 280, 283, 286, and 287).

The best background for the cray-fish would be the plan of the "*Successive forms of the astacomorphous type*," as given by Huxley in his work on the cray-fish, page 345 (New York, 1880). The geological horizons at the side should be in colors and designated in large type. Upon the "tablet" attention should be especially directed to the morphology of this style of invertebrate skeleton, and a concise account of the evolution of cray-fishes. Between these "folders" there should be three large charts hung upon the wall in this part of the museum hall. The first of these should represent the "Parallelism of ontogeny and phylogeny", each stage, such as Monerula, or Planula, or Gastrula, to

[1] See a *Course of Elementary Intsruction in Practical Biology*, by T. H. Huxley, LL.D., Sec'y R.S., assisted by H. N. Martin, B.A., M.B., D.Sc., page 70. London, 1883.

be illustrated by a colored figure and the descriptions printed under them.[1]

Our second chart should be an enlarged drawing of *Amphioxus lanceolatus* and of an Ascidian, placed side by side. The comparable parts should be properly lettered and named, and the "tablet" should tell us that in the *Amphioxus* we have the lowest known living vertebrate, the Ascidian being a marine invertebrate, and probably the nearest living kin to the back-boned animals. A very concise account of the anatomy and development of each could be given, using for designation the letters on the figures.

The third chart should be a reproduction, very much enlarged, of Haeckel's plate, entitled, "Single or monophyletic pedigree of the stem of the back-boned animals, based on palæontology" ("History of Creation", Plate xiv, p. 222). This is a very instructive plan, showing the successive geological horizons on one side, with their lines carried across the plate, which are divided by other vertical lines that parcel out the classes and subclasses of the Vertebrate Kingdom. Upon the squares or parallelograms thus formed we have the ramifications, clearly set forth, of the vertebrate tree as it arose from the Laurentian period and was carried up to the present time. It would be a very good idea to have a small case in this part of the museum, showing some well-selected specimens of invertebrates suspended in clear alcohol, as well as a pair of jars containing specimens of *Amphioxus* and the Ascidians. These, taken in connection with the drawings, are sure to make an impression, rarely forgotten, upon the mind of the visitor.

So far as we have gone, our collection will present a very fair idea of the types of animals that are without a skull, as well as of other matters bearing upon general development and morphology.

(2) *Craniota.*

(*a*) HAGS AND LAMPREYS.

We now arrive at a class next higher in the scale, and already alluded to in the review above given, which was evidently developed from the *Acrania*, or skull-less forms (*Amphioxus*). The animals in question are the well-known hags and lampreys, lowly organized vertebrates that have long and deservedly received the closest study from anatomists. No museum of anatomy should be considered complete without them, and as the forms are few, an entire case should be devoted to their proper exhibition. On account of their round mouths, which they use for sucking, they have been called the *Cyclostomata*, and as they are single-nostriled fishes they have been still better called the *Monorrhina*.

[1] For the descriptions without the figures, see Haeckel's *History of Creation*, vol. ii, p. 127.

This subclass has been clearly and concisely characterized by a prominent ichthyologist in the following terms:

Skeleton cartilaginous and notochordal, without ribs and without real jaws; skull not separate from the vertebral column; no limbs; gills in the form of fixed sacs, without branchial arches, six or seven in number on each side; one nasal aperture only; heart without *bulbus arteriosus*; mouth anterior, surrounded by a circular or subcircular lip, suctorial; alimentary canal straight, simple, without cæcal appendages, pancreas, or spleen; generative outlet peritoneal; vertical fins rayed.[1]

From such a perishable structure it can be readily understood why no fossil forms have been preserved for us. Very important gaps occur in consequence.

The hag (*Myxine glutinosa*) is a northern marine parasitic fish that occasionally bores its way into the bodies of other fishes, such as the common cod. *Myxine* is related to the lampreys, some of the principal points of structure in which it differs from them being as follows: (1) a single, circular, membranous tube represents the entire auditory organ, whereas in the lampreys (*Petromyzonta*) it is further differentiated; (2) the nasal sac opens into the pharynx, while in the lampreys it terminates blindly above it.

There are several forms of lampreys, the best known one perhaps being *Petromyzon marinus*. This is a marine species that ascends the rivers on our east coast and the west coast of Europe to spawn. The young of the lamprey differs so much from the adult that it was at one time described as a different genus (*Ammocœtes*). Now, our case should contain alcoholic specimens of the hag (*Myxine*), and young and old specimens of the lampreys (*P. marinus* and *fluviatilis*). The background of the case should also be thoroughly illustrated with good anatomical drawings of their several parts, and there should be an enlarged cast of the *brain* of *Petromyzon*. The brain and other parts should also be exhibited in alcohol, and the development of the sense organs should receive special attention. Every part should also be properly lettered in good type. A good skeleton is particularly essential, and as this is secured only with difficulty, it being entirely cartilaginous, I will present the method as given by an eminent zootomist. This author says:

The preparation of the lamprey's skeleton is a very laborious process, owing to the extreme toughness of the connective tissue which invests it. Removal of the latter is assisted by maceration in nitric acid (10 per cent.), care being taken not to allow the acid to act too long, the result of prolonged maceration being the entire separation of the cartilages of the skull proper and the total destruction of the branchial basket. In preparing a skeleton for demonstration purposes it is, however, advantageous to allow the cartilages to separate, and then to articulate them with fine platinum wire. The branchial basket can then be shown by itself in a special dissection. The skeleton may be either kept in spirit or prepared as follows:

(*a*) Place for about three days in a solution composed of glycerine, 10 parts; water, 10 parts; corrosive sublimate, 0.1 part; alum, 0.2 part.

---

[1] Albert Günther, M.D., F.R.S. Article *Ichthyology*, in the *Encyclopedia Britannica*, ninth edition, vol. xii, p. 694.

(*b*) Transfer to melted glycerine jelly made by dissolving 2 parts of gelatine, or gelatine glue, in the above fluid; allow to remain for two to four days at a temperature just sufficient to keep the jelly fluid.

(*c*) Place in a dry room until the surface no longer feels damp or sticky; then varnish with a solution of white (bleached) shellac in rectified spirit.[1]

The skeleton of *Petromyzon* thus prepared should be mounted on a black-walnut stand, as already suggested. A "tablet" should appear on this case giving the necessary and clear description of these important forms—the CYCLOSTOMATA or MONORRHINA.

(*b*) FISHES.

The class of fishes (*Pisces*) is an exceedingly large one, and volumes upon volumes have been devoted to the science of ichthyology. Still, one can but marvel as he sees the new and strange species that are constantly brought to light from all parts of the world. Of the habits of many fishes we know a good deal, and much in a general way of their anatomy, but little of the great mass, which is as yet uninvestigated and unknown. A brief review of their classification has been given above; but the question now arises, how are we to choose from this enormous array of forms in order to give any adequate idea of them, their almost infinite number of shapes, and their anatomy? So far as the collection is concerned, there are three principal things we must have in mind. In the first place, the exhibition must be so chosen and arranged in the museum hall that the intelligent examiner can derive a clear notion of the anatomy of the class in general, and of the broad principles of their morphology, relations, developmental advances, and position from a structural point of view.

Secondly, in addition to such specimens as we must borrow from other countries and waters to illustrate special points in ontogeny and phylogeny, the collection must present the greatest number of forms from the country in which the museum is found. The foreigners we choose must be pretty well-known and striking examples.

Finally, on the other hand, there must be a very fair proportion of foreign specimens among the disarticulated skeletons of the genera, in the division where that material is kept. These remarks apply with equal force to the other vertebrate classes, and will not be referred to again.

We must devote one "folder" to the fish section, with its usual explanatory tablets. The "leaves" of this must have enlarged drawings, showing principally the methods of ovulation of the various subclasses; the embryology; selected subjects in special anatomy, as the circulatory system of a typical teleost; organs of special sense; the swim-bladder and some of its modifications, and several other such leading and more important points in the anatomy of the class.

[1] T. Jeffery Parker, B.Sc., London. *A Course of Instruction in Zootomy* (Vertebrata), pp. 1, 2. London, 1884.

The dark backgrounds of the cases cannot be better utilized than by having neatly fastened against them good casts of the ancient types of fishes, or their restorations by competent authorities. These should be concisely explained by tablets in large print.

The earliest fishes were *Ganoidei* (gar-fish, sturgeon, and mud-fishes) and *Placoidei* (sharks, skates, and rays). But few of these types now exist, and most have long since become extinct. They were the first vertebrates, and arose in the Devonian age, their appearance constituting the grandest step in advance in the progress toward the subsequent forms that were to inhabit the earth.

The chief restorations in casts presented of the Devonian placoids should be, *Pteraspis*, *Cephalaspis Lyelli*, *Pterichthys cornutus*, *Coccosteus decipiens*, *Holoptychius nobilissimus*, and *Osteolepis*.

Of the lepidoganoids we should have a cast each of the restoration of *Diplacanthus gracilis* and *Glyptolemus Kinairdii*.

One or two of the prominent piscine forms of other geological epochs and ages should also be chosen, until we carry them up to include such types as the teleostean *Beryx* and *Osmeroides* of the Cretaceous. A chart upon the wall between two of the cases could give enlarged drawings of the nearest living allies of the Devonian fishes, such as *Lepidosiren*, *Polypterus*, *Cestracion Philippi*, *Ceratodus*, *Lepidosteus*, and *Amia calva*, with the necessary information regarding each species printed under it. Then every one of these forms should be represented in the cases by a well-mounted skeleton, alcoholic preparations of *brain*, *heart*, and *viscera*, and, if necessary, other special parts, such as the optic commissure of *Amia*, and the air bladder of others. The sturgeon (*Acipenser*) and the paddle-fish (*Polyodon folium*) should be represented in a like manner.

Then comes another exceedingly important group that should be treated in precisely the same way, the whole being well labeled with explanatory tablets giving the necessary information. This group includes the *Selachii*, or the sharks and rays; in it should be found such forms as—

Notidanus.
Chimæra (sea-cat).
Squatina (monk-fish).
Carcharias (blue shark).
Mustelus (hound).
Squalus (dogfish).
Sphyrna (hammer-head).
Pristis (saw-fish).
Lamna (porbeagle).
Acanthias (spiny dogfish).
Pristiophorus (Australian shark).
Raja batis.
Torpedo (the torpedo).
Trygon (sting-ray).
Myliobatis.

These barely represent the leading types, and may be added to in several directions with advantage. It is evidently impossible to call attention to all the numerous anatomical lessons these various genera illustrate, and I can do nothing more than insist that the same plans be pursued as recommended with the ganoids. There is much in the an-

atomy of the sharks and rays that gradually leads us up to the higher Vertebrata. Particular care should be bestowed upon the skeletons and the teeth, as also upon drawings and casts of brains, nervous systems, and other special parts. The literature of the subject is quite full.

As I have stated, the great legion of existing fishes are teleosteans. These are far more highly developed and specialized than the *Elasmobranchii* and *Ganoidei*, of which we have just been speaking; in fact, teleosteans are the highest in the scale, in point of development, of all known fishes. In structure they differ principally from the lower forms in having a thoroughly ossified skeleton and differentiation of the numerous bones of the skull; in possession of gills (usually four), which are defended by a group of opercular bones; finally, by decided advances in the nervous and arterial systems.

The classification of the *Teleostei* is by no means a settled question among systematic ichthyologists. Indeed, such writers hold various opinions upon the question as to the number of orders into which they should be divided. Huxley[1] divides them into six groups, based upon their general structure; Haeckel,[2] into two legions, viz., those having an air passage to the swimming bladder and those without it. These legions are again divided into five orders. Packard, in his "Zoology", presents us with eight orders, a division in which, I believe, so eminent an authority as Dr. Gill concurs. Finally, Dr. Günther gives us six orders (Encyclopedia Britannica, ninth edition, article Ichthyology), which substantially agree with Professor Huxley's groups.

Now, if we take as an example the piscine fauna of North America, so extensive is it, even in the matter of skeletons alone, that for the mounted collection it would be highly impracticable to give specimens of all the species. I see no reason, however, why it should not be perfectly feasible to make the attempt to present a well-mounted skeleton of the typical representative of each genus. This would make a very valuable series, indeed, and an excellent basis for study, particularly if taken in connection with a well-selected exhibit of the soft parts in alcohol. I will say, in passing, that though the soft parts should never be neglected, still the osteological specimens must always, throughout the Vertebrata, of necessity, form the most important part of the collection. In short, if there can be such a thing as one system being of greater importance than another, then the most important of all is the osseous system.

Even if our museum should possess a perfectly mounted series of the North American genera of fishes, there are certain forms of the teleosteans to which anatomists have specially devoted themselves, and which are chosen as examples of the class in manuals of comparative anatomy.

[1] T. H. Huxley. *A Manual of Anatomy of Vertebrated Animals*, p. 143. New York, 1872.

[2] *History of Creation*, vol. ii, p. 208.

As a few of these, I may mention the cod (*Gadus morrhua*), the pike (*Esox lucius*), the salmon (*Salmo salar*), and the perch (*Perca*).

This being the case, we should choose one of these forms, say a large-sized cod, perfect in every particular so far as its skeleton is concerned, and have this part of its anatomy thoroughly cleaned and disarticulated. It should next be mounted in such a manner that the bones will hold their relative positions, but at the same time be distinctly individualized, or thrown apart, as we have seen human skulls prepared. The specimen, supported above a black walnut stand, should be placed in a case with glass sides and a dark background, against the wall on the level with the eyes. The bones of the skull and other parts of the skeleton should be lettered in good-sized type, with abbreviations standing for their proper names; as *Sq.*, squamosal; *Pr. O.*, preoperculum, etc. An explanatory "tablet" should be at the side. The skeletons of the other fishes mentioned by me should be awarded prominent places in one of the main cases. In placing the skeletons of the genera in the cases, some authorized classification should be followed as far as practicable. This is very important, and attention should be called to it on the proper tablets. Exotic forms must not be forgotten, and a few good and well-colored casts of existing fishes would be valuable, especially one giving the names of the external parts.

(*c*) AMPHIBIANS.

In our display of the Amphibia, we must be guided by exactly the same principles as we were when treating the fish. We have already seen how the amphibians were foreshadowed by the dipnoan fishes, especially in their skeleton and respiratory apparatus. Indeed, our studies in the anatomy of the two classes prove to us that the divergence must have been very gradual.

In the Amphibia we find well-developed lungs, and in some forms persistent gills; the bones of the skull are reduced in number, and are more comparable with the reptiles, birds, and mammals. The limbs are also more or less homologous with these classes. But it will be impossible here to enter upon the details of structure in this highly important and interesting group; be it enough to say that in their life from egg to adult, in their morphology, and in their metamorphoses, they picture to us the various stages from fish that live in the water to such forms as we might imagine first come to live on the land, or that in fact they show the general tendency toward the higher Vertebrata. A good example of this is seen in "the *tailless* or *frog-like Batrachia* (Anura)", that "during their metamorphosis not only lose their gills, with which in early life (as so-called tadpoles) they breathe in water, but also the tail with which they swim about. During their ontogeny, therefore, they pass through the course of development of the whole subclass, being at first *gilled Batrachia*, then *tailed Batrachia*, and finally *frog-like Batrachia*. The inference from this is evidently that *frog-like Batra-*

chia developed at a later period out of *tailed Batrachia*, as the latter had developed out of *gilled Batrachia*, which originally existed alone." (Haeckel.)

Another very well known and excellent example is seen in a different group of animals of the same class, the salamanders. I tell it in the words of the writer just quoted: "Great interest was caused a short time ago, among zoologists, by the *Axolotl* (*Siredon pisciforme*), a gilled salamander from Mexico, nearly related to the triton; it had already been known for a long time, and been bred on a large scale in the zoological garden in Paris. This animal possesses external gills, like the young salamander, but retains them all its life, like all other *Sozobranchiata*. This gilled salamander generally remains in the water, with its aquatic organ of respiration, and also propagates itself there. But in the Paris garden, unexpectedly from among hundreds of these animals, a small number crept out of the water to the dry land, lost their gills, changed themselves into gill-less salamanders, which are not to be distinguished from a North American genus of tritons (*Amblystoma*), and breathed only through lungs. In this exceedingly curious case we can directly follow the great stride from water-breathing to air-breathing animals—a stride which can indeed be observed every spring in the individual development of frogs and salamanders. Just as every separate frog and every separate salamander transforms itself from an amphibious animal breathing through gills into one breathing at a later period through lungs, so all the groups of frogs and salamanders have arisen from animals breathing through gills, and akin to the *Siredon*. The *Sozobranchiata* have remained up to the present day in that low stage of development. Ontogeny here explains phylogeny; the history of the development of individuals explains that of the whole group." The significance of such metamorphoses, such foreshadowings in the recapitulation of the various stages, can be studied during the embryonic life of even so high a vertebrate in the scale as man. The one or two "folders" devoted to the embryology, and such other points in anatomy as cannot well be shown in any other way, of the Amphibia, must bring out these matters in a strong light. The various stages in the development of a tadpole and its structure must be given, as well as good colored diagrams, on a much enlarged scale, of the nervous and circulatory systems of the adult frog.

As with the fish, the background of the main cases containing the skeletons and other specimens for the Amphibia may be illustrated with casts of ancient members of the group, from *Archegosaurus* of the Bavarian coal-measures down to the present time.

The group, not being by any means as extensive as the class *Pisces*, can be illustrated more generally by a wider choice of skeletons. There are only about 700 species known, 101 of which are found in our country, and 100 fossil forms.

The classification of the Amphibia is still a mooted question, zoologists differing in some particulars. However, they are generally divided into *six orders*, viz.: the *Trachystomata*, the *Proteida*, the *Urodela*, the *Gymnophiona*, the *Stegocephala* (extinct), and the *Anura*.

Some of the principal forms selected from these to illustrate the anatomy of the class should be—

Siren.	*Bufo.*	*Pipa.*
Proteus.	*Rana.*	*Sieboldia.*
Menobranchus.	*Amphiuma.*	*Hyla.*
Salamandra.	*Menopoma.*	*Triton.*
Cœcilia.	*Necturus.*	

A few good alcoholic specimens of *Necturus*, *Menobranchus*, and *Amphiuma* should appear in the cases, as well as the larval forms of *Amblystoma*.

Nearly all these types have received considerable attention at the hands of anatomists, but most particularly the frog (*Rana*) and the axolotl.

The *brain*, *heart*, and *viscera* of all the principal types should be well shown in alcoholic preparations, casts, and drawings, as best suited to each case. The cartilaginous parts of the skeletons can be prepared as recommended for the lampreys.

(*d*) REPTILES.

We now leave the Amphibia and pass to the next highest group of animals, the Reptilia, which in present times includes crocodiles, lizards, snakes, and turtles. Here we find decided advances in organization, and for the first time in ascending the scale the presence of the *amnion* in the embryo. (See table for classification, etc., page 21.)

The Reptilia are divided into eleven orders, six of which are extinct, to say nothing of the enormous number of forms that have died out.

As a class they are characterized as being "air-breathing vertebrates, with limbs usually ending in claws; limbs sometimes absent, rarely paddle-shaped; body scaled; ribs well developed; heart in the highest forms four-chambered; cold blooded; an incomplete double circulation; oviparous; eggs large; embryo with an amnion and allantois; no metamorphosis." (Packard.)

The entire group of existing birds arose, increment by increment, from long-since extinct reptilian forms. Consequently, in addition to illustrating the anatomy of the existing types of the class, this fact must be brought prominently into the foreground. We adhere to the same plan as adopted with the Fishes and Amphibia. The "folders" should illustrate and explain the embryology of the principal types, and give enlarged drawings of such subjects as, (1) "Bones of feet of embryo reptile and embryo bird;" (2) "Head of *Crotalus*, dissected, lateral view;"

(3) "Anatomy of lizard (including brain, heart, etc.), snake, and turtle;" (4) "Comparisons of the several parts of the skeletons of living and extinct forms;" (5) "Longitudinal and cross sections of skulls of the class to show bones of brain case, ear, etc." All these should be lettered and explained by "tablets."

Several cases will be required to contain the collection of skeletons and other specimens for the Reptilia, and, in addition, a small crocodile, a turtle, and a python should be mounted in precisely the same manner as suggested for the cod. As many of the extinct reptiles attained enormous proportions, of course the casts and drawings for the backgrounds of the cases must be proportionally reduced; for instance, *Mosasaurus maximus*, which ought to be represented, was over sixty feet in length. Separate cases in the center of the hall, however, may be devoted to the skeletons of the larger members of the several classes, or even, in some cases, the skeleton or model may stand out, uncovered by glass.

Out of the vast host of extinct forms some of the principal ones to be represented, in cast or drawing, are—

Liodon.	*Plesiosaurus.*	*Edestosaurus.*
Ichthyosaurus.	*Elasmosaurus.*	The *Dinosaurs.*
Dicynodon.	*Pliosaurus.*	

Special parts of other labyrinthodonts, enaliosaurs, rhynchosaurs, and ancient lacertians may be chosen as subjects, particular care being taken, as already suggested, in each instance, to choose those suited to show the *progressive tendency*, either mammal-wards or bird-wards. Of the latter the dinosaurs hold the most prominent place.

Now, although the dinosaurs were reptiles, they foreshadowed many of the skeletal characters of birds, especially of such forms as existing ostriches and their kind. The pelvis and posterior extremities showed this in many instances. Chief among these characters of the dinosaurs are to be noted the long and slender ischium, directed backward; the presence of only three functional toes; the ascending process of the astragalus; the shortened fore limbs; and many characters in the axial skeleton, as a consolidated sacrum. In locomotion some of them walked upright on their posterior extremities, occasionally using the fore feet. They attained ponderous dimensions, the *Atlantosaurus* being eighty feet in length. Other types were the *Hadrosaurus*, *Iguanodon*, and *Cetiosaurus*. As Cope says,

> These were bulky, inoffensive, herbivorous monsters, able to rise up on their hind feet and browse on the tops of trees; their undue increase was prevented by carnivorous forms like *Lælaps*, which was an active, possibly warm-blooded dinosaur, with light, hollow bones, large claws, and serrate, conical teeth. It stood 6 meters (18 feet) high, and could leap a distance of 10 meters through the air.

Some of these forms had their beaks sheathed as in modern birds; some had teeth (*Rhamphorhynchus*); some were without them (*Pteranodon*). Still nearer to the birds came *Compsognathus*, reduced in size,

with long flexible neck supporting a small delicate head, and heavy hind legs with short fore legs, which latter were not evidently used for the purposes of locomotion. It also possessed a long reptilian tail.

One good-sized chart to hang on the wall between the two proper cases should present lateral views, thoroughly lettered and explained, of the pelvis and entire hinder extremity of Dromæus, Dinosaur, and Crocodile, as we find them compared, for instance, in Professor Le Conte's excellent treatise on geology (p. 444, ed. of 1883). This is particularly interesting and instructive in showing the characters of the pelvis, and the final anchylosis of the metatarsal bones which culminated in *Aves*. The final steps of this change, taken just in the nick of time, have been described by Marsh in the case of the *Ceratosaurus:*

> All known adult birds, living and extinct, with possibly the single exception of *Archæopteryx*, have the tarsal bones firmly united, while all the *Dinosauria*, except *Ceratosaurus*, have these bones separate. The exception in each case brings the two classes near together at this point, and their close affinity has now been clearly demonstrated.[1]

Further light will be thrown on this subject when we come to speak of the *Archæopteryx* and the *Odontornithes*.

The same rule with respect to alcoholic specimens must be followed in the case of the Reptilia as in that of the classes heretofore discussed.

The skeletons of the genera are also to be attended to in the same way. In the case of turtles the plastron should be hinged and standing open in some specimens, and one good-sized subject should be chosen to present the names of the bones, being properly lettered and explained.

It is hardly necessary to mention here, though I have not done so before, that in all the vertebrate classes some of the genera are represented only by very diminutive forms. These are unfitted for public exhibition in the vast majority of instances. The public rarely look upon such preparations in any other light than mere matters of curiosity and not of study. The gratification of such curiosity is in no way commensurate with the immense amount of labor it requires to prepare such subjects. In each class a magnified drawing of the skeleton of one of these minute vertebrates might be given, and attention called to a line giving the actual size of the specimen. This would at least show that the same plan of structure holds good even through the tiniest and most delicate of vertebrate forms.

Some of the principal types of Reptilia that should be represented by their skeletons or appropriate preparations of their soft parts, are the following:

Chelone midas (green turtle).
Chelydra serpentina (snapping turtle).
Thalassochelys caretta (loggerhead turtle).
Amyda mutica (unarmed trionyx).
Aspidonectes ferox (soft-shelled turtle).
Cinosternum Pennsylvanicum (mud-turtle).
Emys meleagris (terrapin).

With *Testudo, Cistudo, Xerobates*, and other forms.

[1] Prof. O. C. Marsh. *On the United Metatarsal Bones of Ceratosaurus. American Journal of Science*, Art. xxi, p. 161. New Haven, August, 1884.

Hatteria (the sphenodon).
Ophisaurus ventralis (the glass snake).
Heloderma suspectum (the Gila monster).
Sauromalus ater (alderman lizard).
Sceloporus undulatus (common lizard).

With such other lizards as *Phrynosoma, Cyclodus, Iguana, Draco, Varanus, Chameleon,* and the higher types of another order, *Alligator* and *Crocodilus.*

Crotalus adamanteus (rattlesnake).
Ancistrodon piscivorus (moccasin).
Elaps fulvis (harlequin).
Farancia abacura (horn snake).
Ophibolus doliatus (king snake).
Coluber vulpinus (fox snake).
Pityophis sayi (bull snake).

With specimens of such other snakes as *Bascanium, Eutænia, Tropidonotus, Heterodon, Naja, Python,* and *Boa.*

(*e*) BIRDS.

The anatomy and embryology of the class *Aves*, or Birds, is to be illustrated by means of one or two "folders" after the same fashion as the other classes, while alcoholic preparations must exhibit the brains, hearts, and viscera of the existing subclasses or more important orders. Casts of brains in other instances, such as the ostrich or emeu, are also desirable.

Birds of our day constitute a wonderfully distinct group. The links connecting them with the reptiles have all perished, and complete differentiation has resulted. But as we go back in time, paleontology yields us, and is constantly yielding, most interesting forms which supply the missing members of the series. Marsh has discovered in the most recent horizons of this country both land and water birds closely related to modern types. Europe, still more fortunate, claims sixty or seventy species from the Miocene of France. These were much like many of our present tropical birds, as trogans, flamingoes, and parrots. As we drop into the Eocene (London clay) a very suggestive form has been found, restored and described by Owen as the *Odontopteryx*, a bird that had bony serrations along the edge of the mandibles. The Jurassic *Archæopteryx* of the Solenhofen slates of Bavaria has already been referred to above. Standing out now prominently and alone, it does indeed form a connecting link between birds and reptiles. But we must remember that beyond doubt it had its own ancestors, and was really but one form in the line of descent, and we cannot say what manner of shapes its descendants may have assumed before the race died out. A drawing, or still better, if possible, a cast of both *Archæopteryx* and *Odontopteryx* should be presented.

The doctrine of evolution had taught us to look for still more modern forms of birds, with remains still bearing the impress of their lowly reptilian origin. Many years passed by, however, before such a thing was to be realized. It came at last, and the splendid discoveries of Marsh revealed the very types that might have been expected. These have now become familiar to all of us through the numerous reproductions, reduced from Professor Marsh's originals. They have been pub-

lished far and wide, and in all sorts of connections. Our collection should have life-size charts of the leading forms of these birds, or if very good fortune favored, casts of the same. Life-size photographs are not to be ignored. These birds present a most extraordinary combination and mixture of bird, reptilian, and fish characters in their skeletons.

So extraordinary and exceptional is this combination of characters, that Marsh believes he is justified in placing them not only in new orders, but even in a new subclass. According to this authority, the class of Birds may be divided into two subclasses, viz. *Ornithes*, or true birds, and *Odontornithes*, or toothed birds. And the new subclass *Odontornithes* into three orders, viz.: (1) *Saururæ* (reptile-tailed), represented by the Archæopteryx; (2) *Odontolcæ* (teeth in grooves), represented by Hesperornis; and (3) *Odontotormæ* (teeth in sockets), represented by Ichthyornis.[1]

In the second edition of the "Key to North American Birds," Coues presents us, in Part IV, with a systematic synopsis of the fossil birds of North America. They extend from the Tertiary to include the upper Jurassic of this country, and number forty-six species. Therefore a pair of models showing the striking increase in the size of the brain of modern birds as compared with the ancient forms, would be instructive. A tern and *Ichthyornis* should be chosen for the comparison.

The structure of modern birds, as a class, is an exceedingly homogeneous one as compared with other classes; they differ but little in their anatomy. So in choosing skeletons to illustrate their osteology we must aim to pick out the extremes, choosing forms as far removed from each other as possible, even if we have to ransack the world to attain our object.

Huxley has classified birds according to differences that occur in the structure of the hard palate. Skulls representing these differences and the names of the groups based upon them, should be placed side by side in the case and properly lettered, and explanatory tablets given.

The subclass *Ratitæ*, or birds characterized by a keelless sternum, should be thoroughly represented by the leading forms composing it, as follows:

Struthio camelus (ostrich).
Rhea Americana (South American ostrich).
Dromaius Novæ-Hollandiæ (emeu).
Apteryx Oweni (kiwi).

Some of the fossil or subfossil forms of this subclass would also be a valuable acquisition, as *Dinornis* and *Palapteryx*. Such subjects would make good models for the backgrounds of the cases, and there might be added to the list, with advantage, a cast of the head of the extinct dodo, and a drawing of the skeleton of *Alca impennis*, with such other like objects as may be attainable and illustrative of the anatomy of the class, or of its ontogeny and phylogeny.

The *Carinatæ*, or birds with a keeled sternum, form the great bulk of the class, and the skeletons of the following genera should appear as

[1] Joseph Le Conte. *Elements of Geology*, p. 493. New York, 1883.

the principal types to be represented. As in the other classes, this list, of course, can be enlarged as space and occasion require.

Turdus migratorius (American robin).
Sitta (nut-hatch).
Thryothorus (wren).
Alauda (lark).
Dendrœca (warbler).
Hirundo (swallow).
Passer (sparrow).
Icterus (oriole).
Corvus (crow).
Tyrannus (flycatcher).
Antrostomus (whip-poor-will).
Ceryle (kingfisher).
Picus (woodpecker).
Psittacus (parrot).
Ectopistes (pigeon).
Bubo (owl).
Buteo (hawk).
Tetrao (grouse).
Opisthocomus (hoazin).
Meleagris (turkey).
Numenius (curlew).
Charadrius (plover).
Tringa (sandpiper).
Grus (crane).
Anser (goose).
Cygnus (swan).
Anas (duck).
Colymbus (loon).
Larus (gull).
Rhynchops (skimmer).
Phœnicopterus (flamingo).
Pelecanus (pelican).
Alca (auk).

This list, to be sure, is the merest skeleton in the world, and should be made somewhat comparative, where feasible, and filled out at least to two hundred and fifty specimens. Some of the foreigners and birds from the tropics possess very instructive skeletons, as selections from the trogons, riflebirds, hummers, shrikes, paradise birds, hornbills, toucans, *Gallinæ*, *Ardeidæ*, and *Alcidæ*, will testify.

(*f*) MAMMALS.

We now enter upon the last and at the same time the most important of all the classes of vertebrated animals, the Mammalia. Important from the fact that man himself is a member of it, as well as a variety of forms with which he is more or less nearly related and anatomically comparable. Now, although there is very much in the last three classes discussed that throws light upon the structure of man, still it is here, as we pass from the Monotremata to the Primates, that we must exert all our ingenuity to present such subjects, and in such a way, as will best illustrate the anatomy of the various types of men. It must not be understood, however, that this is to be done to the neglect of much that is of the highest importance, from a morphological point of view, in the structure of others of the class where it may not particularly illustrate man's anatomy. As many of the subjects of this group are very large and cannot in all instances be arranged in the museum hall upon a strictly classificatory basis, we must be more than generous with our explanatory tablets. These must be so placed and contain such clear and concise information, that with a little reading and study on the part of the examiners the whole plan will be clear and the relations evident.

The "folders" must thoroughly illustrate comparative embryology and much that relates to it. Good descriptive drawings of the embryos

of chick, turtle, dog, and man, must be placed side by side. The placentas of the *Villiplacentalia*, *Zonoplacentalia*, and *Discoplacentalia*, must be contrasted by similar methods. All such parts as cannot be represented by the natural objects, casts, or models, should receive like attention, as, for instance, the distribution of nerves and vessels in certain special cases.

I mention here, in passing, that the placenta is discoidal in *Rodentia*, *Insectivora*, *Cheiroptera*, and *Primates*, and the uterus develops a decidua (the *Deciduata*); while in the *Hyracoidea*, *Proboscidea*, and *Carnivora* the placenta is zonary, although they also are deciduate animals. The *Non-deciduata* are the *Ungulata*, *Toxodontia* (?), *Sirenia* (?), and *Cetacea*.

Many of the extinct Mammalia are of ponderous size; still, by a judicious selection and the aid of reduced models and drawings, the various styles of types, as they are at present known to us, can be well shown. The amount of this kind of material now on hand is simply incalculable, and, from an evolutionary point of view, of the highest interest. With the knowledge of these facts, we should only aim to illustrate the general character by a few appropriate and well-chosen examples.

For instance, let one case be devoted to the genesis of the horse. This can be a very shallow one, and placed against the wall. Its background should be rather dark, and at one side, running from top to bottom, there should be an illustration of the geological horizons. Opposite these, arranged in proper rows, should be models of the fore feet, hind feet, fore arm, shank (lateral views), and superior and lateral aspects of molars of the ancestors of the horse, from Eocene to Recent and Quarternary, from proper *Eohippus* to *Equus*. Such an illustration as this, accompanied by an explanatory tablet, would be of an inestimable value from more points of view than an educational one.

It is hardly necessary to remark that I would choose this latter example from the admirable series drawn by Marsh and copied by Huxley, Le Conte, and others.

The increase in size, or growth, of the *brain* should be shown. A chart of some of the best known basins might be given, with good sized cuts of the characteristic Mammalia of each, printed or drawn in the proper places. Show one of the best examples of the generalized types of the extinct Mammalia, as *Coryphodon Hamatus;* also how it is probable that both *horse* and *camel* arose on this continent; and, finally, the relations of the pachyderms and ungulates to existing mammalian fauna. To represent present mammals, we are compelled to make demands upon the faunas of all parts of the world; the general principles of exhibition, however, are to be employed, as far as practicable, as with former classes.

The MONOTREMATA are the first to receive our attention. Complete skeletons of *Ornithorhynchus* and *Echidna* take a prominent place here, and as these animals are quite small, well-mounted specimens would hardly be out of place to show their external characters. Their brains,

circulatory and *generative apparatuses*, and particularly the latter, should be compared with those of some bird of about the same size. The skeleton of a duck placed near that of the *Ornithorhynchus*, with the bones lettered and named, would constitute a valuable comparison, attention being called to the horny sheath of the beak, the shoulder girdle, and the absence of the external ear in each case. *Acanthoglossus Bruijnii* would be a rare acquisition.

The peculiar anatomical features of the next subclass, the MARSUPIALIA, should be clearly set forth, both by wet preparations and a good series of skeletons. Excellent types for this purpose are—

Didelphys Virginiana (opossum).
Perameles lagotis (rabbit-eared perameles).
Phascolarctos cinereus (koala).
Macropus gigas (kangaroo).
Phascolomys ursinus (wombat).

With such other forms as the Tasmanian wolf (*Thylacinus*), the squirrel marsupials (*Petaurus*), and the marsupial ant-eaters (*Myrmecobius*).

Drawings should be given showing the location of the young when quartered in the maternal pouch.

Monodelphia.

We now pass to the MONODELPHIA, the last subclass of mammals, and the one that contains the vast majority of forms. Zoologists are by no means agreed upon the question of classification of this group, but I have given (page 27) a division of it into orders that fairly expresses our present knowledge of these animals. A glance at this will at once convince the reader that it will be impossible in an essay of the present nature to do more than barely allude to the leading characters of this numerous array. In the taxonomy of mammals the teeth always have, and must ever hold, an important place. A chart can easily be presented that will show the methods of writing the dental formulæ and drawings of the leading types, much upon the same plan as given by Owen in his admirable figures.[1] Alcoholic specimens and casts of *brains* become now, if possible, of still greater importance, and the organs of other systems must by no means be neglected.

In the EDENTATA (Bruta) we have a group of animals but little higher in the scale of organization than the marsupials. Their teeth are of a low order of development, and in many instances the cerebral hemispheres are nearly smooth. They either dig or climb, and their feet are formed to meet these ends. The *Megatherium*, *Mylodon*, and *Megalonyx* are prominent examples of their extinct ancestors. They should be represented in the collection by such types as the following:

Bradypus tridactylus (ai).
Manis longicaudata (pangolin).
Dasypus novem-cinctus (armadillo).
Tamandua tetradactyla (ant-eater).
Orycteropus capensis (aard-vark).

These may be added to with advantage, and the wonderful extinct form, the *Glyptodon clavipes*, would be an acquisition.

[1] Richard Owen, F.R.S. *On the Anatomy of Vertebrates*. Vol. iii, pp. 265–382. London, 1868.

The RODENTIA are a very large order, affording us a wide range of forms to select from. They are without canine teeth, and their incisors are very large, reproducing themselves as they are worn off by gnawing. In the lower jaw the condyles are longitudinal and glide forward and backward in their furrows.

Good examples of rodents are —

Pedetes caffer (jumping hare).
Castor fiber (beaver).
Sciurus niger (fox squirrel).
Arctomys monax (woodchuck).
Geomys bursarius (pocket gopher).
Zapus Hudsonius (jumping mouse).
Erethizon dorsatus (white-haired porcupine).

This list, when practicable, should be extended to include many instructive forms of other families.

The PROBOSCIDEA should at least be represented by a skeleton of a moderately-sized elephant, with a section of the skull of the same animal and a cast of its brain.

In the HYRACOIDEA we find the single genus *Hyrax*, two or three species of which are known. These little animals have long puzzled zoologists, no fossil forms having yet been discovered, while the living types have characters associating them with the ungulates, especially the rhinoceros.

The UNGULATA form a large and important group, with nearly all its representatives of very considerable proportions, as the table of orders will show. It will be advisable, however, to obtain at least one skeleton of each of the types there mentioned. As the evolution of this group is very interesting, charts of the proper kind should be hung in the neighborhood of the specimens describing it. The ungulates offer excellent material in alcoholic preparations, in sections of skulls, and in studies of teeth and hoofs. Much of their gross anatomy must be given in diagrams and drawings.

To some extent the SIRENIA, being aquatic forms of Herbivora, connect the cetaceans with the ungulates. The group is small, but can be well illustrated through the American manatee (*Manatus Americanus*). The dugong (*Halicore*) is another species. Within the past century Steller's manatee (*Rhytina Stelleri*) has become extinct, and our knowledge of the series is completed by the Tertiary fossil, the *Halitherium*. In many particulars the anatomy of the group is interesting.

It seems more than probable that the CETACEA were evolved from extinct ungulate forms, and that they early adopted the water as their element. They are mammals in every particular, and from this point of view their structure offers very important material for study. A very instructive method of mounting a skeleton of a whale can be seen in the collection of the U. S. National Museum. A model of the animal has been longitudinally bisected, showing the external appearance on one side, and the skeleton *in situ* on the other, the model being hollow. Casts of the brain of the whale are essential additions to the collection.

The group can be well illustrated by the following types:

Globiocephalus melas (pilot whale).
Phocœna communis (porpoise).
Delphinus tursio (bottle-nose dolphin).
Monodon monoceros (narwhal).
Orca gladiator (grampus).

Among the principal characters that distinguish the CARNIVORA is the super-development of the canine teeth. They have a simple stomach, and, as a rule, their distal phalanges are armed with large claws. Many of their extinct ancestors, from the great development of the canines and general appearance of the skull, had a very ferocious aspect, and must have been savage animals indeed, as, for example, the saber-toothed tiger (*Machairodus cultridens*) from the Pliocene of Europe.

Representative specimens to illustrate the Carnivora are seen in the following list:

Felis leo (lion).
Felis concolor (puma).
Felis domestica (common cat).
Lynx rufus (American wild cat).
Hyæna striata (striped hyena).
Canis familiaris (common dog).
Canis latrans (coyote).
Vulpes velox (swift fox).
Viverra civetta (civet cat).
Herpestes mangusta (mongoos).
Mustela Canadensis (fisher).
Putorius vison (mink).
Gulo luscus (wolverine).
Lutra Canadensis (American otter).
Taxidea Americana (American badger).
Mephitis mephitica (skunk).
Nasua solitaria (coaiti mondi).
Procyon lotor (raccoon).
Ursus horribilis (grizzly bear).
Ursus Americanus (black bear).
Trichecus rosmarus (walrus).
Phoca vitulina (common seal).
Callorhinus ursinus (fur seal).

These may be increased with great advantage; and, in any event, series of skulls of the Carnivora should be exhibited, such as the many varieties of domestic dogs compared with foxes, wolves, and the like, and the same applies to the cats.

Among the INSECTIVORA we find many instances of adaptive organization, numerous subjects full of interest for study, and structures from which the most important deductions may be drawn.

The group contains some very strange forms, as the bat-like *Galeopithecus* and the pentail. Its skeletons and alcoholics should at least be represented by the following list of animals, chosen from the group:

Galeopithecus volans (flying lemur).
Ptilocercus Lowii (pentail).
Macroscelides tetradactylus.
Erinaceus Europæus (hedgehog).
Sorex platyrhinus (shrew).
Scalops aquaticus (common mole).
Myogale moschata.
Potamogale velox.
Centetes ecaudatus (tenrec).
Chrysochloris obtusirostris.

The shoulder girdles and upper extremities of several members of this group should be compared and their modifications explained.

The tenth order in our list includes the CHEIROPTERA, or the bats, for whose exclusive reception it is constructed. This thoroughly circumscribed group of animals was at one time (by Linnæus) classed with the Primates, owing principally to the fact that they had pectoral mammæ; but they at last have been (by Huxley) awarded their proper place in the system, being regarded as extremely modified *Insectivora.*

The situation of the mammæ is now known to be a modification in organization that has come about thróugh the necessity of having the young in such a position during the flight of the mother. A moment's reflection will convince us of the necessity of this. No little attention has been paid to the structure and natural history of this interesting group, and a review of either would take far too much space in the present connection. The tablets, however, should invite attention to the modification of the skeleton for the purposes of aerial locomotion, and to the really low order of the brain. There is a large number of species of bats in the world, but they are divided primarily into two groups, the fruit-eating and the insectivorous.

Their anatomy may be well shown by skeletons, alcoholic preparations, and drawings of the following forms:

Plecotus auritus (long-eared bat).
Vespertilio pruinosus (hoary bat.)
Natalus micropus.
Thyroptera tricolor.
Megaderma gigas.
Triænops persicus.
Emballonura raffrayana.
Taphozous longimanus.
Nyctinomus macrotis.
Pteropus poliocephalus (roussette bat).
Rhinolophus unifer (horseshoe bat).

In our eleventh and last order, the PRIMATES, I have placed the various species of men and the monkeys. This arrangement, however, is upon purely provisional grounds, and notwithstanding the immense amount of study that has been bestowed upon the various members of this group and the very extensive literature that refers to it, I am of the opinion that our knowledge of the subject, taken from all points, is simply in its veriest infancy, and that we have barely gained a foothold upon the outermost boundary of the immense territory yet to be explored.

The leading thinkers and zoologists of the day entertain very diverse views upon the various questions relating to this group. Many of these will undoubtedly be permanently settled as time passes on and our knowledge of the subject becomes more complete. It yet remains to be settled, among other things, whether the lemurs should not be removed from the Primates by common consent, as the bats have been; whether man should occupy an order by himself (*Bimana*), or a separate suborder or family of the Primates; and again, whether there are one or more species of men.

A word here as to the lemurs, as these animals are not familiar to many of my readers. They are interesting chiefly from the fact that we still find prominent zoologists who believe that they ought to be retained in the same order with man.[1]

[1] See St. George Mivart, F.R.S., *On Lepilemur and Chirogaleus, and on the Zoological Rank of the Lemuroidea* (*Proceedings of the Zoological Society*, 1873, p. 484), as one of the highest authorities on retaining them among the Primates, and M. Alphonse Milne-Edwards as holding contrary views, in *Observations sur quelques points de l'embryologie des Lémuriens et sur les affinités zoologiques de ces animaux* (*Annales des Sciences Naturelles*, October, 1871); also P. Gervais, *Encéphale des Lémures, Journal de Zoologie*, tome 1, p. 7.

The existing species are not numerous, and do not diverge widely in their organization or habits, being all of small or moderate size, all adapted to an arboreal life, climbing with ease, and, as they find their living, which consists of fruits, leaves, birds' eggs, small birds, reptiles, and insects, among the branches of the trees, they rarely have occasion to descend to the ground. None are aquatic, and none burrow in the earth. Many of the species, but by no means all, are nocturnal in their habits, spending the day in sleeping in holes, or rolled up in a ball, perched on a horizontal branch, or in the fork of a tree, and seeking their food by night. Their geographical distribution is very peculiar; by far the larger proportion of species, including all those to which the term "lemur" is now especially restricted, are exclusively inhabitants of Madagascar, where they are so abundant and widely distributed that it is said by M. Grandidier, who has contributed more than any other traveler to enrich our knowledge of the structure and manners of these animals, that there is not a little wood in the whole island in which some of them cannot be found. From Madagascar, as a center, a few species less typical in character extend through the African continent westward as far as Senegambia, and others are found in the Oriental region as far east as the Philippine Islands and Celebes.[1]

The writer is very much inclined to believe, with Professor Cope, that the common ancestor of lemurs, monkeys, and men, will eventually be traced to some such group as the ancestors of the *Condylarthra*, etc. *Very recent discoveries of remains in the Eocene of Wyoming, in this country, strongly point in that direction.*

Haeckel believes that "the strange flying lemur in the South Sea and Sunda Islands (*Galeopithecus*), the only remnant of the group of *Pteropleura*, forms a perfect intermediate stage between semi-apes and bats. The long-footed semi-apes[2] (*Tarsius*, *Otolicnus*) constitute the last remnant of that primary branch (*Macrotarsi*), out of which the Insectivora developed. The short-footed forms (*Brachytarsi*) are the medium of connection between them and genuine apes. The short-footed semi-apes comprise the long-tailed lemur, the short-tailed *Lichanotus*, and the *Stenops*, the latter of which seems to be very closely allied to the probable ancestors of man among the semi-apes.[3] Notwithstanding the fact that the lemurs lie in the line of the ancestors of man (Tertiary or Eocene), I am of the opinion that the existing forms are at present sufficiently differentiated from the apes to be assigned to an order by themselves. The anatomy of the lemurs should be illustrated from such types as the following:

Tarsius spectrum (specter tarsier).
Indris brevicaudatus (short-tailed indri).
Propithecus coronatus.
Lemur cotta (ring-tailed lemur).
Loris gracilis (graceful lemur).
Nycticebus tardigradus (slow lemur).
Avahis laniger (wooly avahi).
Galago crassicaudatus.
Cheiromys Madagascariensis (aye-aye).

[1] W. H. Flower, F.R.S. Article *Lemur*, *Encyclopedia Britannica*, ninth edition, vol. xiv, page 440. A minute anatomical *résumé* of the Lemuridæ will be found here.

[2] Semi-apes is another term used for lemurs (*Prosimiæ*).

[3] *History of Creation*, vol. ii, pp. 256 and 257. A little further on in his discussion of this subject Professor Haeckel says that "no semi-ape, either living or in a fossil state, has as yet been found in America." Since that was written Marsh has taken fossil skeletons from the Eocene beds of the Rocky Mountains, of which he says that the principal parts of the skeleton are "much as in some of the lemurs." So it may be that even some of the Primates have originated on this continent.

The lemurs are connected with the apes and monkeys, as we ascend the scale, through the *Marmosets*, which are monkeys themselves, though these gregarious, squirrel-like, little creatures hardly appear so. Several forms of them are found in South America. They have a long, non-prehensile tail, an elongated, non-opposable thumb, curved and pointed claws on all the digits except the hallux, with specified differences in the dentition and certain brain characters.

It is very important that they should be represented in their anatomy, and perhaps the best types for this purpose are—

Midas chrysoleucus (golden marmoset).
Hapale jacchus (black-eared marmoset).

The marmosets are the first to be classed with the Primates, and we have finally to discuss the remainder of the order, or the apes and men. At the present writing this becomes quite an easy matter, it being rendered so during the past ten or twelve years by the unstinted popularization of the excellent works of such eminent men as Huxley,[1] Vogt,[2] Büchner,[3] Rolle,[4] and many others. And, as far as the anatomy of man alone is concerned, although it is by no means an exhausted subject, its literature is exceedingly rich. Then, too, when we come to illustrate his structure, through any or all of the methods employed in the other classes, we find our task is rather *a choice* from the immense assortment of such material, manufactured or prepared, than *to devise* models or suggest what ought to be done in that line. Men have not spared their ingenuity to imitate their own organization through an infinite variety of means.

MEN AND APES.

We have seen the gradual perfection of structure and its increasing complexity and specialization as we have ascended the vertebrate scale. As we now stand upon the last few steps of the ladder, I say—and of course my reader expected nothing else—strictly compare, both individually, in each case for its own sake, and collectively, for the better knowledge of ourselves and nature's laws, the many forms of apes and the many forms of men.

---

[1] T. H. Huxley. *Evidences as to Man's Place in Nature*, and an innumerable series of brilliant critiques and addresses since, which have been delivered on both continents.

[2] Carl Vogt. *Vorlesungen über den Menschen, seine Stellung in der Schöpfung und in der Geschichte der Erde.* 2 Bände. Giessen, 1863.

[3] Ludwig Büchner. *Die Stellung des Menschen in der Natur, in Vergangenheit, Gegenwart, und Zukunft.* Leipzig, 1870.

[4] Friedrich Rolle. *Der Mensch, seine Abstammung und Gesittung im Lichte der Darwin'schen Lehre von der Art-Entstehung, und auf Grund der neueren geologischen Entdeckungen dargestellt.* Frankfort-on-the-Main, 1866.

But as we stand before this material in our museum hall, let us carry clearly in our minds the true and final expressed convictions of the great and wise laborers in this most important of all fields. For "we must, however, acknowledge, as it seems to me, that man, with all his noble qualities, with sympathy which feels for the most debased, with benevolence which extends not only to other men, but to the humblest living creature, with his God-like intellect, which has penetrated into the movements and constitution of the solar system, with all these exalted powers, Man still bears in his bodily frame the indelible stamp of his lowly origin."—(Darwin.) Long, careful, and painstaking study since has proved that "whatever system of organs be studied, the comparison of their modifications in the ape series leads to one and the same result,—that the structural differences which separate man from the gorilla and the chimpanzee are not so great as those which separate the gorilla from the lower apes."—(Huxley.) "I shall, therefore, confine myself to stating the most important general conclusion resulting from their thorough comparison with man, namely, that each one of the four man-like apes stands nearer to man in one or several respects than the rest, but that no one of them can in every respect be called absolutely the most like man. The orang stands nearest to man in regard to the formation of the brain, the chimpanzee in important characteristics in the formation of the skull, the gorilla in the development of the feet and hands, and, lastly, the gibbon in the formation of the thorax. * * * I must here also point out what in fact is self-evident,—that not one of all the still living apes, and consequently not one of the so-called man-like apes, can be the progenitor of the Human Race."—(Haeckel.) "*The ape-like characteristics of man* are by no means concentrated in one or another race, but are distributed in particular parts of the body, among the different races, in such a manner that each is endowed with some heirloom of this relationship—one race more so, another less; and even we Europeans cannot claim to be entirely free from evidences of this relationship."—(Weisbach.)

It would be entirely out of place here to attempt an enumeration of the anatomical differences or agreements between men and apes, however briefly done. I merely present another one of Professor Haeckel's admirable tables, to show the grouping of apes into families and genera. There is no reason why a well-endowed institution should not possess a skeleton of every one of these forms, and in many cases alcoholic preparations of the soft parts, the anatomy of some of the young, and a few well-assorted casts of brain and other systems.

It is hardly necessary to remind the reader that in this table the genera 1 and 2 have already been discussed; that 21 does not now exist, and that of *Homo* I shall have something to say further on.

SYSTEMATIC SURVEY OF THE FAMILIES AND GENERA OF APES.

I. Apes of the New World (*Hesperopitheci*), or Flat-nosed Apes (*Platyrhini*).

Sections of apes.	*Families of apes.*	*Genera of apes.*	*Systematic names of the genera.*
A. Platyrhini with claws. Arctopitheci.	I. Silky apes, *Hapalida.*	1. Brush ape.	1. Midas.
		2. Lion ape.	2. Jacchus.
B. Platyrhini with blunt nails. Dysmopitheci.	II. Flat-nosed, without prehensile tail. *Aphyocerca.*	3. Squirrel ape.	3. Chrysothrix.
		4. Leaping ape.	4. Callithrix.
		5. Nocturnal ape.	5. Nyctipithecus.
		6. Tail ape.	6. Pithecia.
	III. Flat-nosed, with prehensile tail. *Labidocerca.*	7. Rolling ape.	7. Cebus.
		8. Climbing ape.	8. Ateles.
		9. Wooly ape.	9. Lagothrix.
		10. Howling ape.	10. Mycetes.

II. Apes of the Old World (*Heopitheci*), or Narrow-nosed Apes (*Catarrhini*).

C. Tailed catarrhini. Menocerca.	IV. Tailed catarrhini, with cheek-pouches. *Ascoparea.*	11. Pavian.	11. Cynocephalus.
		12. Macaque.	12. Innus.
		13. Sea cat.	13. Cercopithecus.
	V. Tailed catarrhini, without cheek-pouches. *Anasca.*	14. Holy ape.	14. Semnopithecus.
		15. Short ape.	15. Colobus.
		16. Nose ape.	16. Nasalis.
D. Tailless catarrhini. Lipocerca.	VI. Human apes. *Anthropoides.*	17. Gibbon.	17. Hylobates.
		18. Orang-Outang.	18. Satyrus.
		19. Chimpanzee.	19. Engeco.
		20. Gorilla.	20. Gorilla.
	VII. Men. *Erecti. (Anthropoi.)*	21. Ape-like man or speechless man.	21. Pithecanthropus. (Alalus.)
		22. Talking man.	22. Homo.

DIRECTIONS FOR THE DISPLAY OF THE ANATOMY OF MAN.

The anatomy of man should be attended to, and placed on exhibition by means of the various methods already suggested. Everything that our ingenuity prompts should be taken advantage of; and the ruling idea should be to have everything done in a comparative way. Both sexes ought to be represented with an impartial completeness; not only that, but both sexes of the young, from the earliest stages through the most important steps to maturity. All manner of models, real or manufactured, should be brought into play, in order to make a clear exposition of the entire field. Fœtal men and fœtal apes of different ages should be contrasted by the most convenient processes, and the various systems of their adult bodies should be placed side by side for study. One very important thing is a complete adult human skeleton, with the correct name printed on every bone in a legible type. This skeleton should stand in a case by itself, with all the sides of glass, so that it may be thoroughly seen and studied. There should be a series of skulls of the various types of men, arranged so that they can be compared; also casts of brains and heads of every size and form, from that of Cuvier to that of the veriest idiot. The organs of sense should be illustrated by enlarged models, and the several stages of dentition, from the infant to the youth, by skulls with the necessary parts properly removed.

In purchasing such subjects, it should not be done in a hap-hazard way, but we must have a clear idea of all that our collection illustrates, and where the important gaps really exist. A good healthy museum, when once fairly started, seems to grow any way, and all that such a growth seems to demand is an intelligent guidance.

COMPARATIVE ANATOMY.

We still have left another class of subjects for our collection, the discussion of which I now introduce as the "Comparative Series" of homologous structures. The doctrine of evolution would naturally lead us to look for corresponding parts in all animal forms, however diverse they may have become, or however profoundly modified. For instance, if we found a lachrymal bone in a prairie chicken, why not in a coyote, the original type from which they both sprung having had one? In fact, both have the bone in question, but in the fowl the lower jaw articulates with the skull, through the intervention of a free bone—the quadrate. This is not the case with the coyote. Quite often such variations can be traced to their origin and satisfactorily explained. Herein lies the great value of comparative anatomy; for in the course of unraveling such problems, our researches are often carried into man's own structure, and points in his anatomy that could not be explained in any other way are finally solved; while, still more important than this, we arrive often at the solution of some one of nature's laws or fundamental principles.

To demonstrate the methods through which such valuable deductive conclusions are drawn, I have made a series of drawings which I here present. They are designed to illustrate the legend of the poet Goethe's discovery of the premaxillary bones in man To those who appreciate

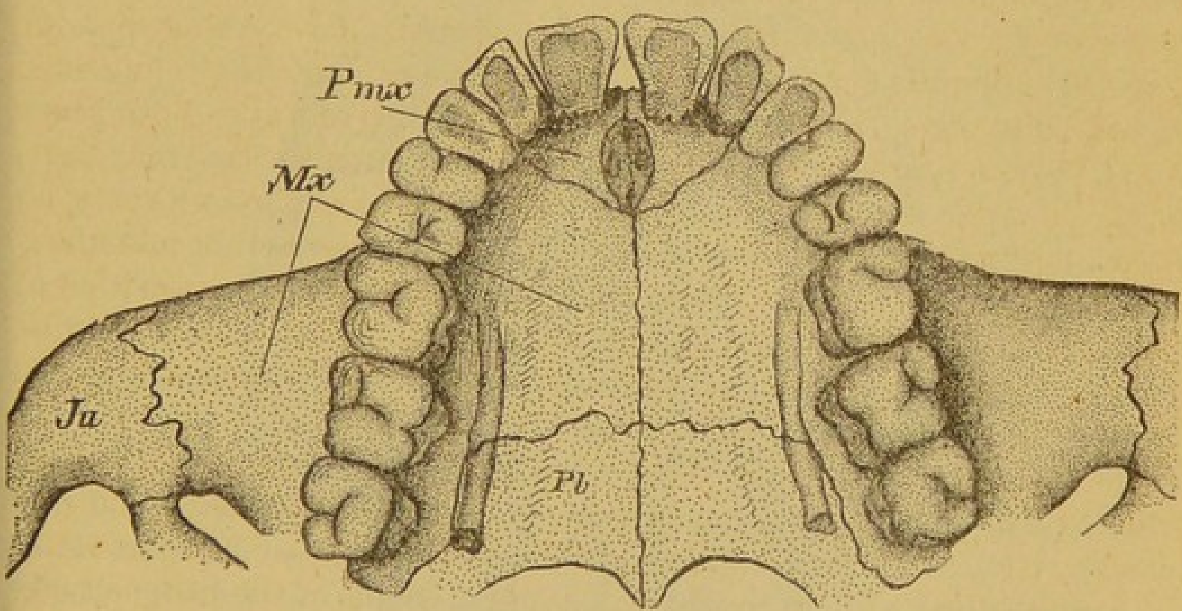


FIG. 1.—Anterior inferior aspect of a man's skull (negro), life size; a specimen of an adult in which the premaxillaries remained persistent throughout life. *Pmx*. right PREMAXILLARY; *Mx*, maxillary; *Pl*, palatine; *Ju*, jugal.

the high importance of the acquisition of every new fact added to our knowledge, however abstruse that fact may be, I have nothing to say; but to those who insist that only such additions to our stock of human knowledge as will benefit the practical aims and ends of life should be sought, I point to the one ray of light that was shed upon surgery through knowledge of the fact that the premaxillaries exist in a man's jaw,

and surely we must admit that surgery is a practical science. Goethe made many individual researches in comparative anatomy, and the discovery I speak of was one of his triumphs. He was already aware of the presence of these bones in most of the vertebrates known to him, yet he had never discovered them in a man. In those days he was opposed by the celebrated Peter Camper and other formidable comparative anatomists, who held this as one of the principal differences between man and the apes; in fact it was *the* human characteristic. Goethe, however, convinced as he was that man was but a highly developed mammal, examined hundreds of human adult skulls, until finally his search was rewarded by the discovery of the premaxillaries in one of them. We are now familiar with its development, and how in some cases these bones show their sutural traces throughout life. Such an instance I present in my drawing (Fig. 1). I believe it occurs far more frequently in the lower types of the blacks than among any of the other races. To show the position of these bones in one of the higher mammals, I have taken the liberty to copy Professor Mivart's admirable inferior view of the skull of the domestic cat.[1]

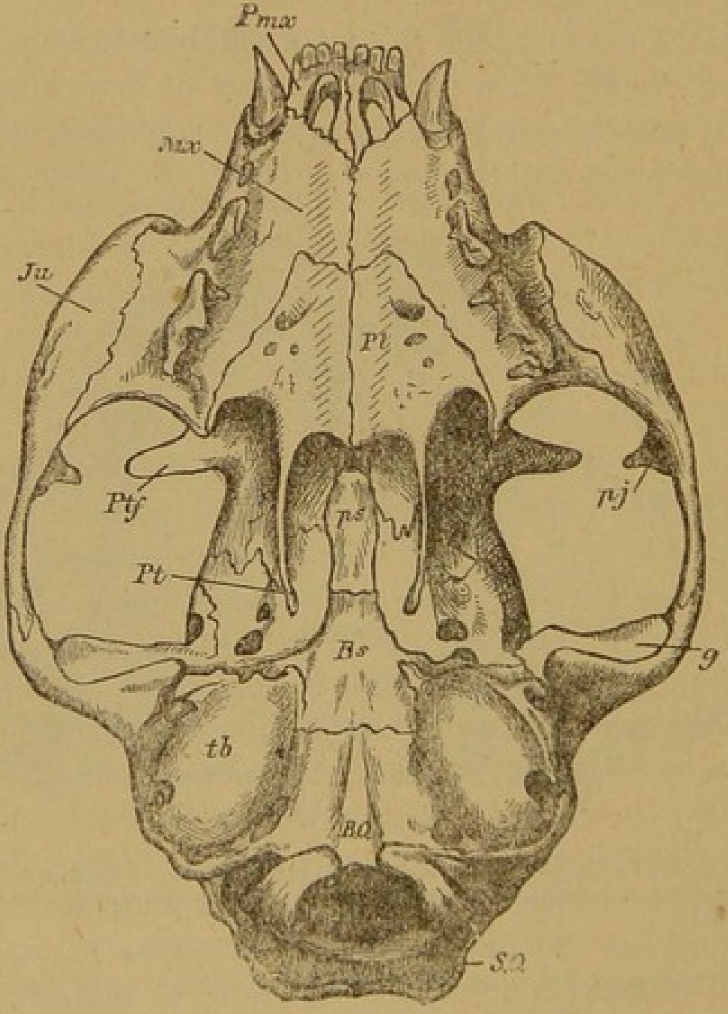


FIG. 2.—Basal view of the skull of the common cat, life size (after Mivart). *Pmx*, PREMAXILLARY; *Mx*, maxillary; *Ju*, jugal; *Pl*, palatine; *ps*, presphenoid; *Bs*, basi-sphenoid; *Ptf*, postorbital process of frontal; *pj*, postorbital process of jugal (molar); *Pt*, pterygoid process; *g*, glenoid surface; *tb*, auditory bulla; *B. O.*, basi-occipital; *S. O.*, supraoccipital.

[1] St. George Mivart, Ph.D., F.R.S. *The Cat: An Introduction to the Study of Back-boned Animals, especially Mammals*, p. 58, Fig. 29. New York, 1881.

As we pass down the scale of mammals, we find this bone constantly changing, until at last we arrive at our lowly organized and bird-like *Echidna*, an animal of which we have said not a little above.

The premaxillary in the *Echidna* resembles very much indeed that bone as we find it in a young ostrich, forming as it does the tip of the beak. This can be appreciated by comparing it with the premaxillary of the chicken. These bones unite to form one in birds.

I have selected my figure (Fig. 3) of the *Echidna* from the excellent cut given by Flower in his "Osteology of the Mammalia", only I have brought my drawing up to life size, Professor Flower's being somewhat reduced.

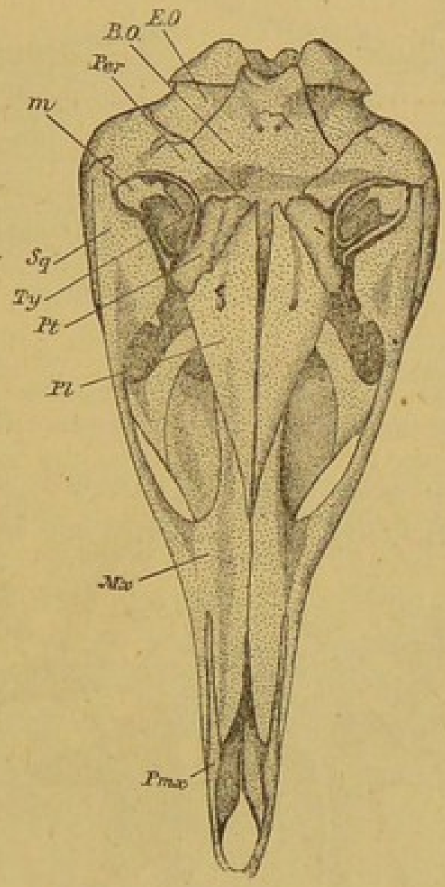


FIG. 3.—Basal aspect of skull of *Echidna hystrix*, life size (after Flower). *E. O.*, exoccipital; *B. O.*, basi-occipital; *Per*, periotic; *m*, malleus; *Sq*, squamosal; *Ty*, tympanic; *Pt*, pterygoid; *Pl*, palatine; *Mx*, maxillary; *Pmx*, PREMAXILLARY.

This skull offers an exceedingly instructive study when compared with series of skulls of birds and the lower mammals.

In order to show the relations of the premaxillary in ordinary birds I have chosen the common fowl. My drawing (Fig. 4) is somewhat modified from Parker's figure in his valuable article, "Birds," in the ninth edition of the Encyclopedia Britannica. The lower cut shows the under surface of the bill, taken from another figure in the same article.

The anatomy and embryology of the common fowl have been quite exhaustively studied by several anatomists, and their researches have resulted in throwing light upon much that would otherwise be obscure, or perhaps forever unknown.

Among the fish the premaxillary assumes a great variety of forms. I have chosen as an illustration the skull of the ordinary large-mouthed

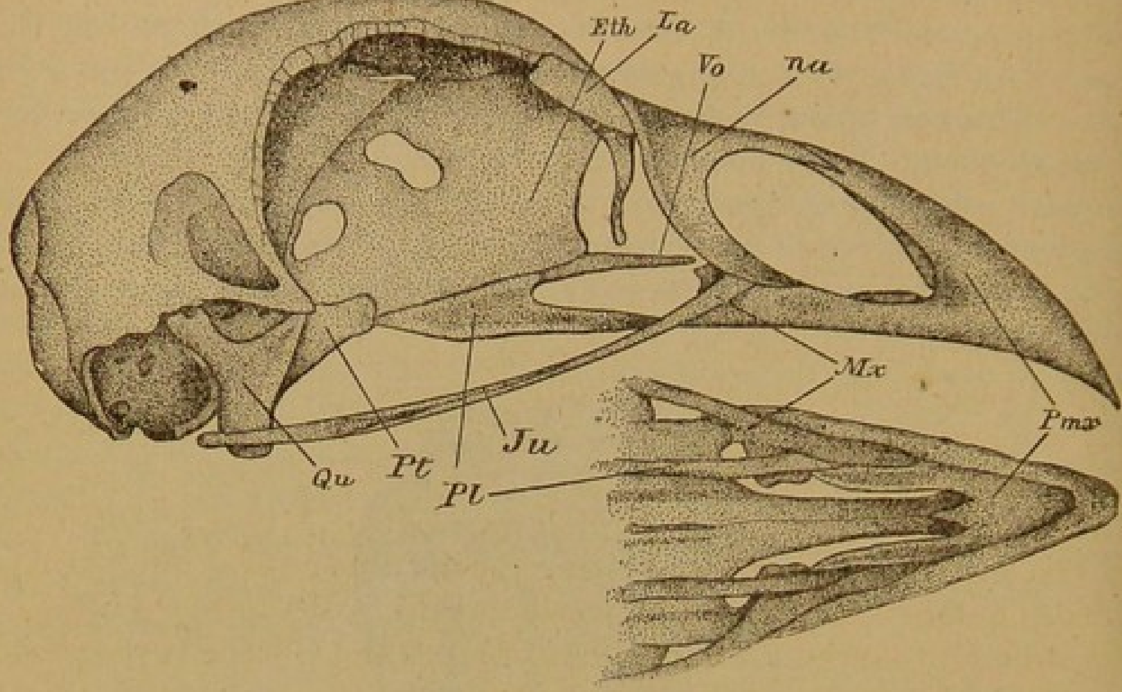


FIG. 4.—Right lateral view of skull of adult common fowl; lower figure, inferior aspect of beak of same specimen (after Parker; somewhat altered). *Pmx*, PREMAXILLARY; *Mx*, maxillary; *na*, nasal *Vo*, vomer; *La*, lachrymal; *Eth*, ethmoid; *Ju*, jugal; *Pl*, palatine; *Pt*, pterygoid; *Qu*, quadrate.

black bass (*Micropterus salmoides*). My drawing (Fig. 5) is from a specimen in my private collection, and shows very well the appearances of

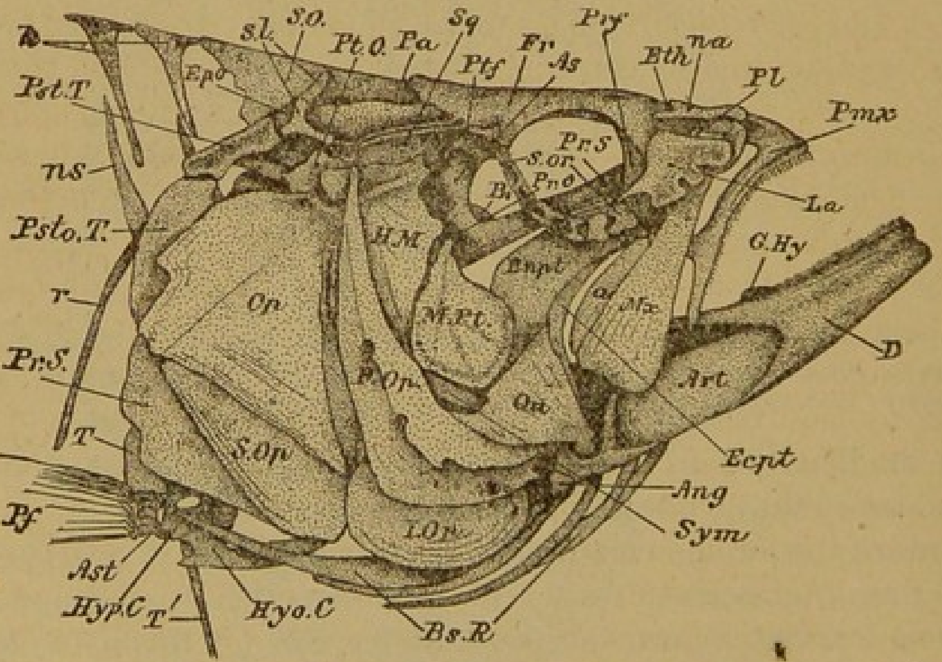


FIG. 5.—Right lateral view of skull of Large-mouthed Black Bass (*Micropterus salmoides*), with other bones; life size, from dissections by the author: *Pmx*, PREMAXILLARY; *Pl*, palatine; *na*, nasal; *Eth*, ethmoid; *Prf*, prefrontal; *As*, alisphenoid; *Fr*, frontal; *Ptf*, postfrontal; *Sq*, squamosal; *Pa*, parietal; *Pt. o*, pterotic; *S. O.*, supraoccipital; *s. l.*, supralinear; *Ep. o*, epiotic; *k*, interneural spines; *La*, lachrymal; *Pr. s*, parasphenoid; *S. or*, suborbital; *Pr. o* proötic; *Bs*, basisphenoid; *G. Hy*, glossohyal; *D*, dentary; *Art*, articular; *Mx*, maxillary; *a*, admaxillary; *Enpt*, entopterygoid; *Ecpt*, ectopterygoid; *M. Pt.*, metapterygoid; *Pst. T.*, posttemporal; *Pr. S.*, proscapular; *Pf*, pectoral fin; *Hyo. C.*, hypocoracoid; *Op*, operculum; *S. Op.*, suboperculum; *Ang*, angular; *Sym*, symplectic; *ns*, neural spine; *Psto. T.*, posterotemporal; *T*, teleotemporal; *T'*, lower teleotemporal; *Bs. R.*, branchiostegal rays; *P. Op.*, preoperculum; *I. Op.*, interoperculum; *H. M.*, hyomandibular; *Qu*, quadrate; *r*, rib; *Ast*, actinosts; *Hyp. C.*, hypercoracoid.

ie premaxillary in ordinary fishes, where it is armed with fine teeth and 'eely articulates with the neighboring bones. Some fish have the power f protruding this bone and again retracting it, as in the case of *Spa-us insidiator.*

In addition to the embryological drawings in the "folders," and in ddition to the skull in each of the classes with separate bones, we hould have a case containing the complete skull and hyoid apparatus f a man, of an ape, of a dog, of a large ostrich, of a python, and of a unny or other good fish. These should be mounted *à la Beauchêne*, with ach bone bearing from one to three letters representing its abbreviated ame. Then there should be a large-sized *papier-mâché* model giving ie ideal plan of the mammalian skull, showing the relations of the ones, the exits of the nerves, and other points. This ought, of course,) be lettered, but it should be of such a size as to admit of putting ie full name on each of the separated segments. A case of this kind iust also contain a model illustrating the old theory that the skull is ivided into four vertebræ, as suggested many years ago by Professor)wen, who reproduced the arguments of Oken and Goethe in the prem-ses. This model should clearly show, by giving different colors to he various segments of the neural and hæmal arches, their supposed livisions according to the theory. It should be accompanied by an en-arged vertebra, with its parts colored and lettered in the same way. ll of the sides of this case should be glass, so that its contents may be xamined from as many points as possible. A tablet conveniently ocated should give the full names for all the abbreviations on the skulls, concise explanation of the other models in the case, and state how, in the Owenian theory of the skull, the scapular arch is attributed as æmal arch to the occipital vertebra, to which it is indeed attached in he fish. The elements of the arch are suprascapular and scapular bones pleurapophysis), coracoid bone (hæmapophysis); hæmal spine absent. Ir. Parker's analysis of the shoulder-girdle, hereafter noted, inval-dates these determinations."[1] The tablet should explicitly state how natomists now regard this theory, and that it is practically obsolete.

Not many months ago, while I was engaged upon a series of dissec-ions of the black bass (*Micropterus*), I was so fortunate as to discover pair of true ribs, articulating upon the occipital bone, above and on ither side of the foramen magnum. This constitutes, I believe, the first ase of this kind scientifically reported, *and certainly militates against he assumption that the scapular arch can ever be considered as the hæmal rch of the occipital vertebra.*[2] This question has always been such an

[1] William Miller Ord, M.B., London, M.R.C.P. *Notes on Comparative Anatomy: A Syllabus of a Course of Lectures delivered at St. Thomas's Hospital*, p. 115. London, 871.

[2] R. W. Shufeldt. *Osteology of Micropterus salmoides. Science*, vol. iii, No. 65, p. May 2, 1884, and No. 72, p. 749, June 20, 1884. Cambridge, Mass.

important one in morphology, and so interesting in many respects that it seems to me to fully merit an illustration here, and I have consequently made a drawing for that purpose.

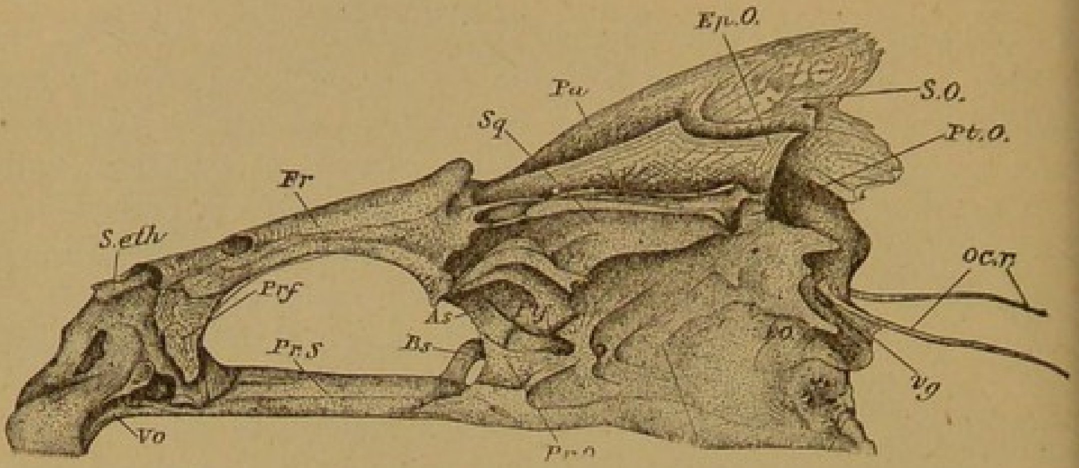


FIG. 6.—Left lateral view of cranium of Black Bass (*Micropterus salmoides*), showing a pair of ribs a he occiput; life size, from nature, by the author from his own dissections: *S. eth.*, supraëthmoid; *Fr* rontal; *Sq*, squamosal; *Pa*, palatine (not well in sight); *Ep. O.*, epiotic; *S. O.*, supraoccipital; *Pt. O.* terotic; *oc. r.*, occipital ribs; *vg*, foramen for vagus; *E. O.*, exoccipital; *B. O.*, basi-occipital; *Op. O.* opisthotic; *Pr. O.*, proötic; *Ptf*, postfrontal; *As*, alisphenoid; *Bs*, basi-sphenoid: *Pr. S.*, parasphenoid *Prf*, prefrontal; *Vo*, vomer.

Another very important case should contain a set of human skulls to illustrate the differences among the *prognathous*, *orthognathous*, *dolichocephalic*, and *brachycephalic* skulls, while a good typical specimen should show what is meant by the "olfactory angle," "occipital angle," and the "cranio-facial angle." This case should also contain a series of longitudinal median sections of intermediate mammalian skulls, ranging from a rodent to man. Here, too, we can exhibit our casts of the Neanderthal and Engis skulls. A tablet should describe the contents of the case. Ah! if we could but show in our growth of the skull the complete series of images that must have fallen upon the retinæ during the labors and life of so distinguished and patient an observer as Professor Parker, whose good work still goes on, then indeed might we exclaim with him—

The mind both of the reader and the writer will be strengthened as well as refreshed by a wider view, and each separate type will be seen in the light of many other types. Indeed, thus alone will it be possible to obtain broad views in vertebrate morphology, "as a man conveniently placed in some eminent station may possibly see, at one view, all the successive parts of a gliding stream; but he that sits by the water's side, not changing his place, sees the same parts only because they succeed, and those that pass make way for them that follow to come under his eye." I must confess to having subjected myself to this mole-like burrowing into so limited a territory that I may obtain fresh material for ratiocination—"that way of attaining the knowledge of things by comparing one thing with another, considering their mutual relations, connections, dependencies, and so arguing out what was more doubtful and obscure from what was more known and evident."

To have worked out one single species in this way may seem to be but like the forming of a single track in a primeval forest; yet, when well cleared, so perfect is

ie unity of each subkingdom, by such a narrow path the worker is regularly led on hrough the labyrinths of nature, when still new discoveries are successively made, very further inquiry ending in a further prospect, and every new scene of things ntertaining the mind with fresh delight.[1]

As we pass from our cases and other material illustrating the morhology of the skull, we should next have a case gotten up on the same rinciple, and devoted to studies and progressive series to demonstrate he evolution, specialization, and final perfection of the sense organs. The almost universal sense of touch, as exemplified in the various ypes of living forms in nature, can only be shown by the proper drawngs of the terminal nerve filaments and other structures subservient hereto. We are all familiar with the low order of this sense, the first vidences of its existence being observed, I may say, in the *Protozoa.*

The evolution of such an organ as the eye, carried through the vaious stages of specialization as seen in successive forms as we advance rom the sea-anemone to the higher vertebrates, is a study full of signifiance and interest. The great importance of comparative anatomy is ere made evident, and the "teleology which supposes that the eye, such s we see it in man or one of the higher Vertebrata, was made with the recise structure which it exhibits, for the purpose of enabling the animal which possesses it to see, has undoubtedly received its death-blow." Huxley.) Our investigations will show that it is a simple spot of pigent in the lowest forms, where such a structure first begins to make ts appearance, distinguishing only the light from the darkness, and his probably only for the extremes. As we ascend we find added to his organ a sensitive nerve; still higher, a lens; then the refractive nedia follow. The eye does not even always occur in the head, but nay be found in some forms on the thorax, or perhaps the abdomen, nd Huxley and Gegenbaur have demonstrated that the eyes of cephalpods and of vertebrates are not even homologous; this applies also o *Amphioxus.*

Equally interesting is the development of the ear; and its numerous tages of transition have been subjected to the same long and patient tudies.

The ears of Crustacea are sacs formed by inpushings of the integument filled with uid, into which hairs project, and which contain grains of sand (which have worked n from the outside) or concretions of lime. These [ears] are situated in the shrimps nd crabs at the base of the inner antennæ, but in certain other lower Crustacea, as in *Mysis*, they are placed at the base of the lobes of the tail.[2]

Models, or the natural objects, if of sufficient size, should *certainly* be presented, showing the homologies, special adaptations, and changes n the *auditory ossicles* in the various vertebrate animals. Such models should show how the malleus, the upper part of the lower jaw in some

[1] W. K. Parker, F.R.S., and G. T. Bettany, M.A., B.Sc. *The Morphology of the Skull*, p. 359. London, 1877. These philosophic passages first appeared from Mr. Parker's pen in 1870, in his *Memoir on the Frog*, p. 201.

[2] Packard.

forms, has in man been reduced in size, and disassociated, and entered the ear through the Glaserian fissure, where it has become a functional element in the ear. The *incus* is seen in the great *hyomandibular* of the fish (*H. M.*, Fig. 5), and such examples are numerous as we enter this subject.

The organs of smell should be exhibited in a like manner in this case.

All this, comparative anatomy has done for us, and through it alone man has acquired a knowledge of the origin and the intimate relations of structures, which knowledge stands opposed to the *mere descriptions of such structures*, whether they be made by the human anatomists of the present day, who ignore all advance in anatomy, or are found in the antiquated works upon the subject written in the sixteenth century. Listen to the words of a man who thoroughly appreciates all that I have said in connection with this matter. Dr. Coues, in writing of "The Nature of the Human Temporal Bone," says:

> This is by far the most diversely as well as most extensively compounded bone of the human body, composed of elements as numerous and as curious as the ingredients of a prescription in the classic days of medicine; but, unlike the latter, the formula of the temporal bone is of no uncertain plan or purpose. But no adequate idea can be acquired of its structure from examination, however minute and protracted, of the bone when all traces of its original composition have been lost by the consolidation of its elements. Such inspection is little more than a vacant stare at a singularly shapeless, meaningless figure of numerous parts, processes, and perforations, knowledge of which may indeed be gained by an effort of memory, but is not, therefore, an acquisition of the understanding. Nothing has so seriously retarded—indeed, has so effectually precluded—a correct appreciation of the nature of the temporal bone, as the custom of describing it only under its final aspect as divisible into squamous, petrous, and mastoid parts, with statement of the principal pieces that are separate at birth—without reference to the forms it wears in other vertebrates, without distinction between intrinsic parts and extrinsic processes, without recognition of the radically diverse elements which enter into its composition, without appreciation of the true relations of the bone to those about it. However sharply interrogated in such fashion, the temporal refuses to give up its secrets, the key to which is far to seek in the depths of embryology, by following link after link of the chain which comparative anatomy lets down into that living well of knowledge.

Cases, and the other methods I have suggested from time to time in this Paper, should be allotted to the exhibition of the anatomy of the remaining organs. Their evolution has been governed by precisely the same laws, and they present us with studies even more instructive than those I have just briefly reviewed for the organs of sense. My space will barely allow me to hint at these in passing. Most important of all of them are the *organs of digestion*. All animal life must eat in order to live and grow, and the manner in which the parts subservient to this function, from *Amœba* to *Homo*, have become more and more complicated, is truly astonishing. The mere study of the mouth and teeth, apart from the remainder of the apparatus, simple or complex, is of the greatest interest.

It is thus we must proceed with our cases and drawings, through the nervous system, the organs of circulation, the organs of respiration, and

the organs of reproduction. The plan for all will be the same; every specimen should occupy its proper place, and be placed there with a definite purpose in view, and *not as a mere isolated object of curiosity.*

There is still another class of subjects of the very highest importance, that should appear in a museum of anatomy, illustrated in the best manner that each specimen will admit of. These are examples of *rudimentary organs.* Nearly every living form possesses such structures, and the doctrine of evolution, in many instances, can account for their presence; indeed, it is the only law that will satisfactorily explain them. They are the heirlooms of pre-existing ancestral forms that are slowly becoming functionless, through disuse and the lack of their further necessity on the part of the organization where they occur. They are to the law of evolution what the way a retreating ship disappears at sea is to the proof of the rotundity of the world. Examples of them are seen in the group of external muscles attached to the concha of the external ear of man; in the plica semilunaris of the inner canthus of the human eye; in the sightless eyes of cave-fishes; in the teeth of embryo cetaceans and ruminants; in the rudimentary lung in certain reptiles, and ovary in birds; in the rudimentary tail of man and the muscles attached to it; and in many hundreds of cases in the skeletons of Vertebrata. Several years ago I dissected a specimen of an American lizard that had no sign whatever of external limbs; indeed, the ordinary observer would have declared that my specimen was a snake. Yet in this form I found a shoulder girdle and pelvis and limbs of a most primitive type,[1] while a year or two later I gave their further advance in a widely different form.[2] Such an example as is furnished by the pectoral and pelvic limbs of *Opheosaurus*, could be strikingly illustrated by means of a good and enlarged drawing of the parts. A circle representing the cross-section of the external integuments, inclosing the figure of the other parts, would tell the story. An explanatory tablet, giving details as full as space will permit, should be attached to our case of rudimentary organs.

Still another class of subjects that are sometimes full of instruction and demand careful collection and attention, are *monstrosities.* Whenever we are so fortunate as to discover, no matter in what animal, any case that clearly points to reversion, it must be prepared with the greatest nicety, and a careful description of it given, including all that it teaches. There are cases on record of the human fœtus having been born with the coccygeal vertebræ free and separately covered by the integuments, constituting a true tail. Here, "though it thus becomes in one sense more perfectly developed, it may at the same time be con-

[1] R. W. Shufeldt, M.D., U.S.A. *Remarks upon the Osteology of Opheosaurus ventralis.* Proceedings United States National Museum, vol. iv, p. 392. Washington, 1881.

[2] R. W. Shufeldt.. *The Habits of Murænopsis tridactylus in Captivity, with Observations on its Anatomy. Science*, vol. ii, No. 27, p. 159. Cambridge, August 10, 1883.

sidered as an arrest of development, and as a case of reversion."[1] Under this head come also supernumerary mammæ and digits, or other parts; in every such instance we must carefully try to discover, if we can, the persistence of an embryonic condition.

THE CATALOGUE OF THE MUSEUM.

It only remains for me now to present one more suggestion in connection with our museum. The books in the library of course will be catalogued, but it is even of greater importance that the collection should be properly catalogued also. A well-prepared work of this description is of the highest value, and enhances the usefulness of a collection manyfold; in fact, it is an indispensable condition of success. Catalogues should be bound in one volume, but they should likewise be split up and bound in various parts, as "Osteology of Reptiles," "Muscular System of Man and the Anthropoids," or "Rudimentary Organs." They should be plentifully distributed about the museum hall, and in the case of the volume representing the catalogue of the entire collection, placed upon light and convenient little tables in desirable localities. Chairs should also be supplied in order that people may sit at these tables and examine the catalogues at their leisure.

The general plan of the catalogue should be an epitome of the collection, and should agree with it in its divisions into sections, its arrangements, and specially in its classification. Moreover, it should be illustrated, and thoroughly illustrated. In these days of electrotypes, and many other cheap and excellent processes, this can easily be done. Certain truths can be given in anatomy in the catalogue through such means as cannot well be exhibited by the collection. At all events, *short*, *clear*, and *concise* accounts of the physiology of the organs must be given in each case, and both the general principles and special illustrations of *function* brought out and accompanied by good drawings, where the text can be made clearer by them. A moment's reflection on the part of the reader will convince him of the great practical use and assistance such a plan would be. For instance, take the question of Respiration. In the catalogue we would find short accounts, accompanied by the proper illustrations of this subject from Protozoa to the highest vertebrates. In the former we find respiration taking place over the entire body, as indeed it does in the sponges and many other of the lower forms; a few steps higher and we find the filamentous processes of certain polyps and vermes, where these organs may perform also other functions, either prehensile or locomotory. In crustaceans we find the "gills" appearing as modified abdominal feet, or perhaps as attached to the legs on the thorax, while in Insecta respiration is carried on throughout the entire interior of the body by means of a very inter-

[1] Charles Darwin, M.A., F.R.S., &c. *The Variation of Animals and Plants under Domestication.* Vol. ii, p. 76. New York.

esting apparatus. And so we would pass on through the fishes, amphibians, dipnoi, and higher Vertebrata. From the catalogue we resort to the cases, "folders," and other material exhibited for illustration in the collection, and here the anatomy of the subject is presented to us in a comparative way, the entire thing is made clear to our minds, and in the end we have conceived some notion of the operation of one of nature's laws,—its universal and various methods of application as seen throughout living forms. Other matters to be touched upon are Parthenogenesis, Hybridity, Dimorphism, and Polymorphism. Catalogues should be written upon such a plan that they can be followed by supplements at intervals of two or three years, if necessary, such supplements to contain the additions made to the collection, as well as short accounts of the advances in our knowledge of anatomy and physiology during the times they cover.

TIGHT GUTTERS
FROM p.43