With regards of the author

ELEMENTARY VIEWS

OF

THE CLASSIFICATION OF ANIMALS.

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[The matter of the following pages has been prepared principally for the benefit of students, who are in general much more apt to learn names and details than to attain to general views. It is introductory to the printed synopsis of lectures which I annually prepare for my classes, and is now published under the impression that, though but elementary and general, the views which it contains may prove interesting to naturalists, and useful to some of those who may be struggling with the difficulties incident to the study of zoölogy under the heterogeneous methods of classification which are found in most elementary books. Should time permit, it may be followed by illustrations of the details of some of the classes and orders of animals. The writer acknowledges his obligations, as sources of recent information, to Agassiz's Essay on Classification, Dana's Remarks on the Classification of Animals based on Cephalisation, and Huxley's Lectures on Classification, though he cannot follow throughout the systems of any of these authors.]

1. Introductory Remarks.

No subject is at present more perplexing to the practical zoölogist or geologist, and to the educator, than that of zoölogical classification. The subject in itself is very intricate, and the views given as to certain groups by the most eminent naturalists so conflicting, that the student is tempted to abandon it in despair, as incapable of being satisfactorily comprehended.

The reasons of this, it seems to the writer, are twofold. First, zoölogy is so extensive, that it has become divided into a number of subordinate branches, the cultivators of which attach an exag-

gerated value to their own specialties, and are unable to appreciate those of others. Thus we find naturalists subdividing one group more minutely than others, or raising one group to a position of equivalency with others, to which, in the opinion of the students of these others, it is quite subordinate. So also we have some zoölogists basing classification wholly on embryology or on mere anatomical structure, or even on the functions of some one class of organs. Secondly, there is a failure to perceive that, if there is any order in the animal kingdom, some one principle of arrangement must pervade the whole; and that our arrangement must not be one merely of convenience, or of a desultory and uncertain character, but uniform and homogeneous.

The writer of these pages does not profess to be in a position to escape from these causes of failure; but as a teacher of some experience, and as a student of certain portions of the animal kingdom, he has endeavoured carefully to eliminate from his own views the prejudices incident to his specialties, and to take a general view of the subject; and is therefore not without hope that the results at which he has arrived may be found useful to the young naturalist.

Classification in any department of Natural History is the arranging of the objects which we study in such a manner as to express their natural relationship. In other words, we endeavour in classification to present to our minds such a notion of the resemblances and differences of objects as may enable us to understand them, not merely as isolated units, but as parts of the system of nature. Without such arrangement there could be no scientific knowledge of nature, and our natural history would be merely a mass of undigested facts.

At first sight, and to a person knowing only a few objects, such arrangement may appear easy; but in reality it is encompassed with difficulties, some of which have not been appreciated by the framers of systems. The more important of these difficulties we may shortly consider.

1. There are in the animal kingdom a vast number of kinds or species. To form a perfect classification it would be necessary to know the characters or distinctive marks of all these species. To make even a tolerable approximation to a good system, requires an amount of preparatory labour which can be estimated only by those who have carefully worked up at least a few species in these respects.

2. So soon as we have ascertained the characters of a considerable number of species, we find that in their nearest resemblances these do not constitute a linear series, but arrange themselves in groups more or less separated from each other like constellations in the heavens, and having relationships tending with more or less force in different directions. This not only introduces complexity into our systems, but renders it impossible to represent them adequately in written or spoken discourse, or even by tables or diagrams. We think and speak of things in series, but nature's objects are not so arranged, but in groups radiating from each other like the branches of a tree; and our imperfect modes of thought and expression are severely tested in the attempt to understand nature, or to convey ideas of classification to the minds of others.

3. The considerations above stated oblige us to enquire what leading characters we may take as the principal thread of our arrangement, so as to make this as natural as possible and at the same time intelligible. It is simplest to take only one obvious character, as if for example we were to arrange all animals according to their colour or to the number of their limbs; but the greater the number of characters we can use, or the more completely we can represent the aggregate of resemblances and differences, the more natural will our arrangement be, and consequently also the more scientific and useful.

In attempting to weigh the several characters presented by any object, we find some that are of leading importance, others that are comparatively unimportant, though still not to be neglected; and we find that some indicate grades of complexity, others are connected with adaptations to certain uses, and others indicate plan of construction. Due weight must be given to all these kinds and degrees of characters. It is perhaps in the proper estimation and value of their relative importance and different modes of application that the greatest failures have been made.

Keeping in view these difficulties of the subject, we may now proceed to the consideration of the more elementary of the groups in which we arrange animals.

2. The Species in Zoology.

We cannot consider the animals with which we are familiar without perceiving that they constitute kinds or *Species*, which do not appear to graduate into each other, and which can be distin-

guished by certain *characters*. Yet simple though this at first sight appears, we shall find that many intricate questions are connected with it. Our idea of the species is based on the resemblance of the individuals composing it in all the characters which we consider essential. If, for instance, a number of sheep and goats are placed before us, we readily select the individuals of each species. In doing this we give no regard to differences of sex or age, but put the young and old, the male and female, of each species together. Nor do we pay attention to merely accidental differences: a mutilated or deformed specimen is not on that account separated from its species. Nor do we attach value to characters which experience has proved to vary according to circumstances, and in the same line of descent. Such, for example, are differences of colour, or fineness of the hair or wool. The remaining resemblances and differences are those on which we rely for our determination of the species, and which we term essential. We shall find that these essential characters of the species are points of structure, proportion of parts, ornamentation, and habits.

These characters constitute our idea of the species, which we can readily separate from the *Individuals* composing it. The individuals are temporary, but the species is permanent, being continued through the succession of individuals. If all the adult individuals are alike and indistinguishable from each other, then any one may serve as a specimen of the species. If there are differences of sex or *Varieties* subordinate to the species, then a suite of specimens showing these will represent the species. The species is thus an assemblage of powers and properties manifested in certain portions of matter called individuals, and which are its temporary representatives. It follows that the species is the true unit of our classification, and that the indefinite multiplication of individuals leaves this unchanged.

Our idea of the species will however be imperfect if we do not distinctly place before our minds its continued existence in time. This depends on the power of reproduction, whereby the individuals now existing have descended from similar progenitors, and will give birth to successors like themselves. A moment's thought will suffice to show that, independently of this, species could have no real existence in nature. If animals were not reproductive, the species would become extinct after the lapse of a generation. If their reproduction followed no certain law, and

the progeny might be different from the parents, then the characters of the species would speedily become changed, and it would practically cease to be the same. Again, it is necessary that the reproduction of species should be pure or unmixed; for an indiscriminate hybridity would soon obliterate the boundaries of species. It is impossible, therefore, to separate the idea of species from the power of continuous unchanged reproduction, without depriving it of its essential characters.

In like manner it is obvious that we must assume a separate origin for each species, and that we need not assume more than one origin. Practically, species remain unchanged, and do not originate from one another; and if all the individuals of a species were destroyed except one pair, this would, under favourable circumstances, be sufficient to restore the species in its original abundance.

The questions which have been raised as to the origin of species by descent with indefinite variation, and as to the possible creation of individuals of the same species in different places or at different times, are not of a practical character, at least in zoology proper, and the whole burden of proof may be thrown on those who assert such views.

We are thus brought to the definition of species, long ago proposed by Cuvier and De Candolle, and may practically unite in one species all those individuals which so resemble each other that we may reasonably infer that they have descended from a common ancestry. All our practical tests for the determination of species resolve themselves into this general consideration. The only modification of this statement on which even a Darwinian can insist, is, that a sufficient time and great geological changes being given, one species may possibly split into two or more; and since this is an unproved hypothesis, we may practically neglect it, except as a warning to be very sure that we do not separate as distinct species any forms which may be merely varieties of a single species, an error exceedingly prevalent, and which vitiates not a little of our reasoning on such subjects.

The origin of the first individuals of a species may be, and probably is, a problem not within the province of natural history. In the case of vital force it is the same as in the case of gravitation and other forces. We can observe its operation and ascertain the laws of its action, but of the force itself we know nothing. It is to us merely an expression of the power and will of the

Creator. With regard to the creative force or power, we are still more ignorant. We do not witness its operation. We know nothing, except by inference, of its laws; and whatever we may succeed in ascertaining as to these, we may be sure that in the last resort we shall, as in the case of all other natural effects, be obliged to pause at that line where what we call force resolves itself into the will of the supreme spiritual Power. The "miracle" of enactment must necessarily precede law; the "miracle" of creation, the existence of matter or force. Those who deny this have no refuge but in a bald scepticism, discreditable to a scientific mind, or in metaphysical subtilties, into which the zoologist need not enter.

We must not suppose, however, that the species is absolutely invariable. Variability, in some species to a greater extent than in others, is a law of specific existence. It is the measure of the influence of disturbing forces from without in their action on the specific unity. In some cases it is difficult to distinguish varieties from true species, and with many naturalists there has been a tendency to introduce new species on insufficient grounds. Such errors can he detected ordinarily by comparing large suites of specimens and ascertaining the gradations between them, which always occur in the case of varieties, but are absent in the case of species truly distinct. Such comparisons require much time and labour, and must be pursued with much greater diligence than heretofore, in order to settle finally the question whether the varietal perturbations always tend to return to a state of equilibrium, or whether in any case they are capable of indefinite divergence from the specific unity.

The species is the only group which nature furnishes to us ready made. It is the only group in which the individuals must be bound together by a reproductive connection. There might or might not be affinities which would enable us to group species in larger aggregates, as *genera* and *families;* and the tie which binds these together is merely our perception of greater or less resemblance, not a genetic connection. We say for example, that all the individuals of the common Crow constitute one species, and we know that if all these birds were destroyed except one pair, the species would really exist, and might be renewed in all its previous numbers. We can make the same assertion with reference to the Raven or to the Blue Jay, considered as species. But if, because of resemblances between these species, we group them in

the genus *Corvus* or in the family *Corvidæ*, we express merely our belief in a certain structural resemblance, not in any genetic connection. Nor need we suppose that if any of the species of a genus were destroyed they would be reproduced from the others. Further, while all the individuals of any of the species may be precisely similar to each other and still be distinct individuals, all the species of the genus cannot be similar in all their characters, otherwise they would constitute but one species.

In other words, the species and the genus, considered as groups, differ not in degree but in kind. To make this very plain, let us take a familiar illustration. I have a number of maps, all uniform in size and in style of execution; but in the whole there are only two kinds,—maps of the eastern hemisphere, and maps of the western hemisphere. Now all of the maps of *one* kind constitute a species; those of *both* kinds, a genus. The individuals of one species, say of the eastern hemisphere, are all alike. They have all been struck from one plate, from which many similar maps may be produced. But the other map, though necessary to make up the set or genus, may be quite dissimilar in all its details from the first, and could not be produced from its plate. We have no difficulty here in understanding that the specific unity is of a different kind from the generic unity, and that the distinction is by no means one of mere grade of resemblance. A very little thought must convince any one that this applies to species and genera in zoology; and that those naturalists who affirm that species have no more real existence in nature than genera, have overlooked one of the essential elements of classification. Nor would this distinction be invalidated by the assumption of a descent with modification, unless it could be shown that in actual nature species shade into each other; and this is certainly not the case in those which are reckoned as good species.

I have been thus careful to insist on the nature of the species in natural history; because I believe that loose views on this subject have caused a large proportion of the errors in classification.

Though the groups higher than species do not exist in nature in the same sense in which species exist, they are not arbitrary, but depend on our conception of resemblances and differences which actually exist. We go out into the forest and perceive different species of trees; but, at the same time, we find that these species can be grouped in genera, as Oaks, Birches, Maples, &c., under

each of which generic names there may be several species. It is evidently not an arbitrary arrangement of ours thus to group species: they naturally arrange themselves in such groups, under the action of our comparing powers.

3. Genera and Higher Groups.

In comparing species with each other for purposes of classification, there are four distinct grounds on which such comparison can be made. These are :—1st. intimate structural or anatomical resemblance; 2nd. Grade or rank; 3rd. Use or function; 4th. Plan or type. All of these may be, indeed must be, used in classification, though in very different ways.

1. *Intimate structural relationship* is the ground on which we frame *Genera.* Two or more species resemble each other structurally to such an extent that the same definition will in many important points apply to both. Such species we group in a genus. It is most important to observe, as Agassiz has well pointed out, that this close resemblance in structure is really our main ground for the formation of genera. But for this very reason it is not to be expected in our higher groups. It is the mistaken application of this criterion to classes, which constitutes the leading defect of a work otherwise very valuable, and which I cordially recommend to students,—Huxley's "Lectures on Classification."

2. *Grade or rank* refers to degree of complexity of structure, or to the degree of development of those functions that are the highest in the animal nature. A coral polyp is more simple in structure than a fish, and is therefore lower in rank. A fish is less highly endowed in brain, sensation, and intelligence, than a mammal, and is therefore of lower rank. An egg or an embryo is simpler than the adult of the species to which it belongs; and when one animal resembles the embryo of another, it ranks lower in the scale. A worm ranks lower than an insect whose larva it resembles.

We use this difference of grade or rank in grouping genera in *Orders;* but it occupies a very subordinate place in the construction of other groups. Many grave errors have arisen from its indiscriminate application; most heterogeneous assemblages being formed when we construct groups larger than orders merely on the ground of lower grade: and when, on the other hand, we separate the lower members of natural groups on the ground of simplicity of structure, we fall into an equal mistake of another

kind. Of errors of these kinds still current, I may instance the attempt of some naturalists to establish a province or sub-kingdom of *Protozoa*, to include all the simplest members of the Animal Kingdom, and the separation of the Entozoa or intestinal worms from the other worms as a distinct class. The classification in Owen's "Lectures on the Invertebrate Animals," which I have long used with advantage as a text-book, is defective in some parts in this respect.

There are two kinds of investigation much used in classification, which more especially develope the idea of grade or rank among animals. One is that of embryology, or the development of animals from the ovum. Another is that of cephalisation, or the development of the head and organs connected therewith. Both of these are of great importance, but, on the principles above stated, they aid us chiefly in referring animals to their *Orders*. Other limitations of the criterion of grade or rank will appear when we arrive at the consideration of *Classes*.

3. *Function or Use.*—In different animals we often find the same use served by different kinds of organs, as, for instance, the wing of a bird and the wing of an insect, which, though both used for flying, are constructed in very different ways. It would lead us astray were we to arrange animals primarily on this ground: for instance, if we were to group together fishes and crustacea because both swim; or birds and insects, because both fly. Again, in different groups of animals, certain functions and the organs which subserve them are greatly developed in comparison with others. For example, the enormous reproductive power of fishes, or the remarkable development of the locomotive organs in birds, as compared with other vertebrates. This consideration is not applicable in our primary division of animals, but it constitutes the principal ground on which naturalists have based the secondary divisions or *Classes*; and it serves also to indicate the *analogies* between the corresponding members of different primary groups, as, for instance, of the birds in one group to the insects in another.

4. *Plan or Type.*—Under this head we consider the similarity of construction in different animals or organs, without regard to uses. We say, for example, that the wing of the bird and the bat, the paddle of the whale, and the fore-leg of the dog, are similar in type or *homologous* to each other, because they are made up of similar sets of bones. They are modifications of one general plan

of structure. Animals thus constructed on similar plans are said to have an *affinity* to each other.

It is evident that this consideration of homology or affinity, if we can really detect it in nature, should be a primary ground in our arrangement; because, if we regard nature as an orderly system, and still more if we regard it as the expression of an intelligent mind, this must be the aspect in which we can best comprehend its scheme or plan of construction.

As a simple illustration of this and the preceding heads, we may suppose that we are writing a treatise on architecture, or the art of building. We observe 1st, that there are differences of material employed, as stone, brick, or wood; 2nd, that there are various grades of buildings, from the simplest hut to the most elaborate palace or temple; 3rd, we find a great variety of uses for which building are constructed, and to which they are adapted; 4th, there are different orders of architecture or styles, which indicate the various plans of construction adopted. It will, in studying such a subject, be the most logical order to consider, 1st, the several orders of architecture or plans or types adopted; 2nd, under each of these to classify the various kinds of buildings according to their uses; 3rdly, under each of these secondary heads, to treat of buildings more or less elaborate or complex; and 4thly, to consider the materials of which the structures may be composed. This is precisely what the most successful formers of systems have done in natural history, in dividing the animal kingdom into provinces or branches, classes, orders, and genera. On the other hand, classifications produced by mere anatomists who content themselves with a close adherence to similarity of structure and rigid definitions based on these, may be compared to a system of architecture produced by a mere bricklayer, who regards only the materials used and the manner of putting them together.

4. The General Nature of the Animal.

Having settled the more important of the general principles of classification, we now proceed to their practical application; and first, as a necessary preliminary, to ascertain what we understand by the term *Animal*, and what are the *precise limits of the Animal Kingdom*.

In answer to the question, What is an animal? we may say in the first place that the animal is a being possessing organisation based on cell-structures, and vital force. This suffices to distin-

guish it from mineral substances, but not from the plant, which is also organised and living, though in a mode somewhat different.

To distinguish the animal from the plant, we may affirm, 1st, that it is reproductive by eggs and not by seeds; 2nd, that in its processes of nutrition it digests organic food in an internal cavity, subsequently consuming a part of this food at the expense of the oxygen of the atmosphere; and that it builds up its tissues principally of nitrogenised matter; 3rd, that the animal possesses the power of voluntary motion, and, to subserve this, muscular tissue; 4th, that it possesses sensation, and, to subserve this and motion as well, a nervous system and external senses.

We thus find four general characteristics of the animal:

1. *Sensation*—by means of a nervous system and special senses.
2. *Voluntary motion*—by means of the muscular and nervous systems.
3. *Nutrition*—by means of a stomach and intestines, with absorptive, circulatory, and respiratory apparatus.
4. *Reproduction*—by ova and sperm-cells.

In every animal, even the simplest, these functions are in greater or less perfection performed; and it is the presence of the aggregate of these functions or the organs proper to them, that enables us to call any organism an animal. It is important to carry with us this definition of the animal; first, as indicating the limits of the creatures which the zoologist has to classify; and secondly, as pointing out to us the nature of the characters on which we must rely, in our classification. For the student I hold it to be necessary, before proceeding further, to understand well these functions and structures, as they exist in some one of the higher animals.

5. Primary Division of Animals into Provinces or Branches.

This, on the principles already stated, must be made solely on the ground of type or plan, and this taken in its most general aspects.

If we bring before us mentally the several members of the animal kingdom, we shall probably be struck in the first instance with the general prevalence of bilateral symmetry, or the arrangement of parts equally on the right and left sides. We may observe, however, that there is a large group of animals to which

this general style of construction does not apply, and which have, in the words of Agassiz, a "vertical axis around which the primary elements of their structure are symmetrically arranged," conforming in this respect, and also often in other points, to the symmetry of the plant, rather than to that of the more perfect animals. We would thus obtain what is perhaps the most obvious of all primary divisions of animals,—that into those with bilateral symmetry and those that are radiated, or the *Artiozoaria* and the *Actinozoaria* of Blainville. We shall soon find, however, on more detailed examination, that this division is very unequal, since the first group includes by far the greater part of the animal kingdom, and its members are nearly as dissimilar among themselves as any of them are from the radiates.

Penetrating a little deeper into structural character, we find that one large group of the bilateral animals possesses an internal skeleton, arranged in such a way as to divide the body into an upper chamber holding the brain and nervous system, and an under chamber for holding the ordinary viscera; whereas in the greater number of the bilateral animals and all the radiates, there is but one chamber for containing the whole of the organs. The first of these groups, from the vertebræ or joints of the backbone, peculiar to its members, we name *Vertebrata*, and all the other animals *Invertebrata*, as proposed by Lamarck: this division corresponds to the *enaima* and *anaima* of Aristotle. Here also however we have a very unequal division,—the invertebrata being a vast and heterogeneous assemblage.

If, however, after separating the vertebrata on the one hand, and the radiata on the other, we study the remainder of the animal kingdom, we find that it readily resolves itself into two groups, known as the *Articulata* and the *Mollusca*. We thusreach the fourfold division of Cuvier; which is by much the most natural and philosophical yet proposed, however much it may be carped at by some merely anatomical systematists. This system may be summarised as follows:

Provinces or Branches of the Animal Kingdom.

1. VERTEBRATA, including Mammals, Birds, Reptiles, and Fishes. All these animals are bilateral and symmetrical, have an internal vertebrated skeleton, a brain and a dorsal nerve-cord lodged in a special cavity of the skeleton. With reference to the general

form, they may be termed doubly symmetrical animals; with reference to their nervous system, *Myelencephalous.*

2. ARTICULATA,* including Arachnida, or spiders and scorpions; Insects; Crustaceans, and Worms. These animals are bilateral and symmetrical, have an external annulose skeleton, a nervous system, consisting of a ring and ganglion around the gullet, connected with a double abdominal nerve-cord. They are otherwise named *Annulosa*, longitudinal animals, or *Homogangliata.*

3. MOLLUSCA, including Cuttle-fish and their allies; Gasteropods or univalve shell-fishes and their allies; Lamellibranchiates or bivalve shell-fishes, &c.; Brachiopods and their allies. They are bilateral but not always symmetrical, have no skeleton, and an œsophageal nervous ring with nerve-fibres and ganglia not symmetrically disposed. They are otherwise named massive animals, or *Heterogangliata.*

4. RADIATA, including Sea-urchins and starfishes; Sea-nettles and hydras; Polyps and coral-animals; and Sponges and their allies. These have the parts arranged radially around a central axis, and the nerve-system when discernible consisting of a central ring with radiating fibres. They may be otherwise named peripheric animals, or *Nematoneura.*

This fourfold division includes the whole animal kingdom, and is the only rational one which can be based on type or plan of structure. Since the time of Cuvier, though modifications in detail have become necessary, it has been strengthened by the progress of discovery; and more especially Von Baer has shown that the study of embryology establishes Cuvier's branches, by showing that in their development, animals pass through a series of forms belonging to their own branch and to that only.

The attempts which have been made to introduce additional branches or provinces, I regard as retrograde steps. Such for example is the province *Cœlenterata* of Leuckart, including the Polyps and the Acalephs, both of them good classes, but not together constituting a group equivalent to a Province; the Province *Protozoa* of Siebold, which to resume our architectural figure, includes merely the huts and cabins which it is difficult to refer to any style of architecture, but which do not, on that

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* I prefer this term to "Annulosa," as being Cuvier's original name—a fact which should overrule merely verbal objections.

account, themselves constitute a new style; and the Provinces *Molluscoida* and *Annuloida* of Huxley, which, as their names indeed import, are in the main merely simple forms of Mollusca and Articulata.

6. Division of Provinces into Classes.

Having formed our Primary divisions or Provinces on the ground of type or plan, we must, in dividing these into classes, have regard either to subordinate details of plan, or to some other ground. In point of fact, naturalists seem to have tacitly agreed to form classes, on what Agassiz terms the "manner in which the plan of their respective great types is executed, and the means employed in their execution." In other words, they have in forming classes adopted, perhaps unconsciously, a *functional* system, similar to that employed by Oken in forming his primary groups. They have taken the relative development of the four great functional systems of the animal,—the sensative, the locomotive, the digestive, and the reproductive. This is very manifest in the ordinary and certainly very natural sub-division of the vertebrates into the four classes of Mammals, Birds, Reptiles,* and Fishes. The Mammals are the nerve or sensuous animals, representing the highest development of sensation and intelligence. The Birds are eminently the locomotive class. The Reptiles represent merely the alimentary or vegetative life. The Fishes are the eminently reproductive or embryonic class.

If this is a natural division of vertebrates into classes, and if the other three Provinces are of equivalent value, then there should be but four classes in each, one corresponding to each of the great functional systems. We may name the first of these the nervous class; the second, the motive class; the third the nutritive class; the fourth, the reproductive or embryonic class. Let us then endeavour, as a test of the truth of this system, to make such an arrangement of the classes of the animal kingdom.

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* The *Amphibia*, as Dana well argues on the principle of cephalisation, are clearly Reptiles, because we arrange animals in their mature and not in their embryonic condition, and because the points of reproduction in which Amphibia differ from ordinary reptiles, have relation to an aquatic habitat, and are ordinal or rank characters merely.

TABLE OF CLASSES OF ANIMALS.

Provinces or Branches.	Vertebrata.	Articulata.	Mollusca.	Radiata.
1. Nervous class.	*Mammalia*..	*Arachnida* .	*Cephalopoda*.....	*Echinoder-*
2. Motive class...	*Aves*.....	*Insecta*....	*Gasteropoda* (including *Pteropoda*)	[*mata.* *Acalephæ.*
3. Nutritive class.	*Reptilia*....	*Crustacea*...	*Lamellibranchi-* [*ata.*	*Anthozoa.*
4. Embryonic or Reproductive class.	*Pisces*.....	*Annulata*..	*Molluscoida* (including *Tunicata, Brachiopoda, Bryozoa,*.....	*Protozoa.*

All of the above groups are recognized by common consent as classes, except a few which have been already incidentally adverted to, and to which it is not necessary again to refer here.*

It will be observed that the order in descending the columns is that of *affinity;* that in reading across the columns is the order of *analogy*. The affinities no naturalist will seriously doubt. The analogies may be less familiar. In examining them, it will be seen that the first class in each province includes animals remarkable for condensation of the head and body, where the former exists; for high nervous energy, sensation, and intelligence; for prehensile apparatus, and for absence or simplicity of metamorphosis. The classes in the second line are characterized by the greatest locomotive powers in their respective provinces; those in the third line by the development of the nutritive apparatus and of vegetative growth; those in the fourth line by embryonic characters when mature, and by abundant reproductive energy.

It will be observed also as a necessary consequence of the system we have pursued, that each of our classes includes animals of very various rank or grade. Indeed, most of them have at their bases forms so simple or imperfect that it is almost impossible to include them in the class-characters. This is no objection to our arrangement, but a proof of its correctness; for we have now arrived at the point where we must form *Orders* based solely on

* The rank given to the *Arachnida* will be disputed by some naturalists; but a consideration of the structures of these animals will show that their relations to the insects and the crustacea are similar to those of the mammals to the birds and the reptiles; and that it is no more reasonable to say that the arachnidans are nearer to the crustaceans than to the insects, on the ground of general structure, than it would be to do the same in the case of the mammals and the reptiles as compared with the birds.

this consideration of rank. Of these humbler members of our classes we may mention the *Marsupials* and the *Monotremes* among the mammals, the *Amphibia* among the reptiles, the *Mites* among the arachnidans, the *Myriapods* among the insects, the *Entozoa* among the worms. Indeed it is quite possible on this ground to divide each of our classes into two or more *Sub-classes*. This is sometimes convenient for the sake of more accurate definition; but it is not necessary, since the division into orders sufficiently expresses these grades of complexity or elevation.

7. Division of Classes into Orders and Families.

Orders, as already stated, are based principally on rank or grade, to be ascertained by relative complexity or by the development of the higher nature of the animal. The last section, however, obliges us to take this with some limitation; for since we have four descriptions or sorts of classes, each of these must have the grade within it ascertained on special grounds. For example, the orders of birds, insects, gasteropods, and acalephæ, should be ascertained chiefly by reference to the locomotive organs, as being the system of organs most eminently represented in the class. If we glance for a moment at the systems which have been proposed, we shall see that this view has unconsciously commended itself to naturalists. The orders of insects, for example, are very plainly based on such characters, being founded mainly on the wings. This is nearly equally manifest in the ordinarily received orders of birds. It appears in the division into Pteropods, Heteropods, and Gasteropods proper among the Gasteropoda. It is also seen in the orders *Ctenophora*, *Discophora*, *Siphonophora*, among Acalephæ. It would be easy to show by a detailed review of the orders in the animal kingdom, that, in so far as they have been distinctly defined, they have in most cases been framed with a reference to the prevailing characteristics of the class; and also with the idea of grade or rank as a leading ground of arrangement. As previously observed, also, it is in the construction of orders, and in ascertaining rank in other divisions, that embryology and the doctrine of cephalisation are chiefly useful. For the present, however, we must leave this subject until we shall have an opportunity to enter into descriptive zoology.

In Botany, orders and families are identical. In Zoology we use the term *Family* for a group inferior to an order, and equivalent to the sub-order or tribe in botany. The family con-

sists of an assemblage of genera resembling each other in general aspect. Most large orders are readily divisible into such assemblages, which, though in themselves somewhat vague, have the advantage of being formed on grounds which, being conspicuous and obvious at first sight, much aid the naturalist in the preliminary parts of his work. For example, among the carnivorous mammalia such groups as the *Mustelidæ* or weasels, the *Canidæ* or dogs, the *Felidæ* or cats, are so obvious that any member of one of these groups can be referred to that to which it belongs almost at first sight. Still I do not regard families as necessary divisions of the order. Some small orders may not admit of division into families; and even where such division is admissible, the genera may be studied as members of the order, without being grouped in families, though this grouping is often very useful and convenient.

It is important to observe, before leaving this part of the subject, that, in consequence of the great multiplication of species in some groups, and the close scrutiny of their structures, it is the tendency of specialists to form many small genera. This leads to the construction of numerous families, many of which would more properly remain as genera. A still worse consequence is, that, instead of forming sub-orders and sub-classes, such specialists often call sub-orders or even families orders, and raise sub-classes or orders to the rank of nominal classes, thus introducing a confusion which leads the student to suppose that these terms have no definite meaning. I would further observe here, that I do not so much insist on the use of one name for a group rather than another, as on the constant use of each term for groups truly equivalent in the system.

It may be necessary here to state that the formation of orders on the ground of rank, and of families on the ground of general aspect, does not exclude the ideas of rank and general aspect from the province or class. On the contrary, as a secondary ground, general aspect is a good character in the province and class, and a gradation of rank can be perceived in provinces and classes. In the provinces, the *Vertebrata* stand highest, and the *Radiata* lowest, the *Articulata* and the *Mollusca* being nearly equal, and their lower members not so high as the highest *Radiata*; so that they would stand in a diagram thus:

Vertebrates

Articulates *Mollusks*

Radiates.

So among classes, the nerve class in each province is the highest and the embryonic class the lowest, and the other two intermediate; but the idea of rank is not here the primary one, as it is in forming the orders. It is also true that from the province downward the idea of type or plan is constantly before us.

We have now in descending from provinces reached the genera and species, with the consideration of which we commenced; and if the preceding views have been understood, we shall be prepared to commence the study of Descriptive Zoology, or to enter upon the details which fill up the outline which has been sketched. In doing this we must take specimens of known species and study them in their structural and physiological peculiarities, and in their relations to the other species congeneric and co-ordinate with them.