CHAPTER V.

Morphological Differences between different Organisms—"Morphological Types:" their Nature and Constitution—Definition and Consideration of the Six Types or Sub-kingdoms: Protozoa, Cœlenterata, Echinozoa or Annuloida, Annulosa, Mollusca, Vertebrata.

THE differences between different organisms which the study of *Morphology* brings to light are collectively stated under the term "Morphological Types." A careful study of the structural relations of animal forms has revealed the fact that the entire animal series may be divided into six great types or plans of structure; in other words, every animal, considered in relation to its form or morphology, is referable to one or other of these six primary types. Accordingly, when we say that two animals belong to the same "morphological type," we mean that their bodies, however diverse and unlike in external appearance, are constructed or built up on the same primary structural type or plan. And the influence of this important generalisation on the progress of natural science cannot be too highly estimated.

Agreeing in fundamental structure, however, it does not necessarily follow that any two forms should also correspond in the degree to which the "specialisation of functions" is carried out in the economy of each. Hence, having ascertained that two forms agree in being built up on the same fundamental plan, we may employ the physiological means of the "specialisation of functions" to separate and distinguish differences between them. We may thus ascertain that a crab, an insect, and a worm, belong to the same "morphological type;" but a very slight examination of these forms will suffice to show us that the degree to which the "specialisation of functions"

is carried, differs materially in the three cases. We should, therefore, in conformity with our two principles, place them *morphologically* in the same "morphological type;" whilst *physiologically* we should assign each a higher or lower place in the type, according as its functions were specialised to a greater or less degree. These considerations, if borne in mind, will greatly assist us in forming a correct idea of the principles of classification.

Whilst every animal is thus the "resultant" of a morphological tendency on the one hand, and of a physiological tendency on the other, it is exceedingly difficult to give any accurate or absolute definition of what is to be regarded as a true or exact "morphological type;" nor are zoologists entirely agreed as to the correct constitution of certain "types" generally recognised as such. All that need be said, however, on this point, is embraced in the idea that similarity of fundamental structure, as revealed by morphology and development, is sufficient and requisite to constitute a "morphological type."

According to the most generally received and accepted ideas, six primary types or plans of structure are to be defined in the animal series. These types, under the name of "sub-kingdoms," are employed as a basis for our modern classification of the animal and plant worlds, as will be hereafter shown. In the present instance, an enumeration of the chief characteristics of each type will serve to familiarise the student with the great divisions into which the animal series is divided, and will also aid him in the consideration of systematic questions and arrangements.

The animal world is therefore divided into six morphological types or "sub-kingdoms." These, commencing with the lowest in point of structure, are respectively known as the (1) *Protozoa*, (2) *Cœlenterata*, (3) *Echinozoa* or *Annuloida*, (4) *Annulosa*, (5) *Mollusca*, (6) *Vertebrata*. The accompanying illustrations and diagrams will serve to fix the chief structural points of distinction on the mind of the student; and it may be remarked that a correct idea of the "plan" of each type, as diagram-

matised in the figures, will be found of great value in assisting the mind to recognise and retain the essential characters of the respective types.

I. PROTOZOA (Fig. 12, A).—As implied by the name *Protozoa* (*protos*, first; *zoön*, animal), the forms included in this sub-kingdom constitute the most lowly-organised series of the animal world. For the most part the *Protozoa* are aquatic and of microscopic size, and they may exist either as simple and single animals, or in a compound state.

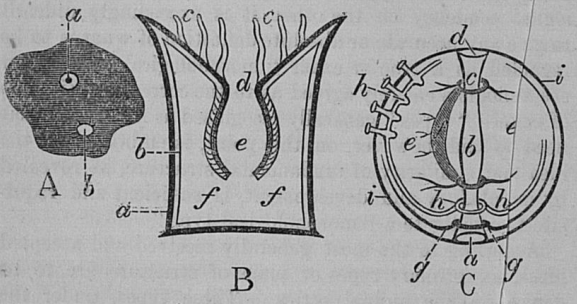

Fig. 12. MORPHOLOGICAL TYPES.

A, Diagrammatic plan of *Protozoön*: *a*, nucleus; *b*, contractile vesicle. B, Plan of *Cœlenterate*: *a*, ectoderm; *b*, endoderm; *c*, tentacles; *d*, mouth; *e*, stomach; *f f*, body-cavity. C, Plan of *Echinozoön*: *a*, mouth; *b*, stomach; *c*, intestine; *d*, anus; *e*, body-cavity; *f*, heart and blood system; *g*, nervous system; *h*, water-vascular or ambulacral system; *i i*, wall of body.

Their bodies are composed of the structureless albuminous material known as "bioplasm," "sarcode," or "protoplasm," and they exhibit throughout a total absence of "symmetry," that is, a definite arrangement of the parts or elements of form. The *Protozoa* are generally destitute of distinct organs of nutrition, circulation, respiration, and innervation. Their reproduction is sexual, or may be effected after asexual methods, as by "gemmation" or "budding," and by simple "fission" or division of the body-substance. In most, if not in all, a solid and more or less central particle, concerned in reproduction, and

termed the "nucleus" (Fig. 12, A, *a*), is found. The "nucleus" may contain a smaller particle known as the "nucleolus." The ultimate constitution of the bodies of the *Protozoa*, as revealed by histology, is generally "unicellular;" that is, consisting of a single and simple "cell." The diagrammatic "plan" of the Protozoa (Fig. 12, A), might therefore be characterised as being no plan at all; since the group is distinguished, as we have just seen, rather by its want of definite and positive characters than by the possession of such distinctive features. An irregular ink-blot, in this respect, might, with the addition of a nucleus, correctly enough express the architectural plan on which the bodies of the Protozoa are built up.

Table of the Divisions of PROTOZOA.

CLASS I.—*Gregarinida*. *Ex.* Gregarina.
,, II.—*Rhizopoda*. *Ex.* Amœba (Fig. 1), Foraminifera (Fig. 2), Radiolaria (Fig. 2).
,, III.—*Spongida*. *Ex.* Sponges.
,, IV.—*Infusoria*. *Ex.* Paramœcium, Vorticella, etc. (Figs. 5 and 22).

II. CŒLENTERATA (Fig. 12, B).—The forms included in this sub-kingdom, or type, are primarily distinguished by the fact, that in all, the general cavity of the body, or "somatic" cavity (*f*), freely communicates with the digestive or alimentary system (*e*), when present; the somatic, or body-cavity of the *Cœlenterata*, being thus in free communication with the outer world through the mouth (*d*). This is simply another mode of expressing the fact that the digestive system (*e*) is but incompletely specialised from the cavity of the body (*f*). Indeed, the term *Cœlenterata* itself, is meant to express this primary characteristic of the sub-kingdom. In this type of structure a distinct "hæmal" blood-vascular, or circulatory system, is wanting; and, save in a few doubtful cases, a "neural" or nervous system is also absent. In the tissues of most, if not of all *Cœlenterata*, certain bodies of variable, but generally of minute size, and termed "thread-cells," or "cnidæ," are found. The function of these urticating or stinging cells is that of offensive or defensive organs, and by means of these bodies the *Cœlenterata*

are enabled to paralyse or kill their prey. Histologically examined, the tissues of the *Cœlenterata* are divisible into two primary layers; the outer layer being termed the "ectoderm" (*a*), and the inner layer the "endoderm" (*b*); and this latter membrane of itself may subserve the digestive function, or may become specialised to form a distinct stomach. True cell-structures, aggregated together, and forming membranes, are thus present in the *Cœlenterata;* this condition forming a striking contrast to the general unicellular structure of the *Protozoa.* Reproduction in the *Cœlenterata* may take place sexually or asexually; the process of "gemmation," or "budding," being seen very typically in the present instance. Lastly, the "symmetry," or disposition of parts in the *Cœlenterata,* is of the "radial" description, but their bodies are also "bilaterally" arranged. The meaning and import of these symmetrical relations will be fully discussed in a future chapter.

Table of the Divisions of CŒLENTERATA.

CLASS I.—*Hydrozoa.*	Cœlenterata, in which the digestive or alimentary sac is not separated from the general cavity of the body; external reproductive organs. *Ex.* Hydra (Figs. 7 and 8), Medusæ, Sea-firs, etc. etc.
CLASS II.—*Actinozoa.*	Cœlenterata, in which a specialised and distinct digestive sac is contained within, and freely communicates with the body-cavity (Fig. 12, B); reproductive organs internal. *Ex.* Sea Anemones, Coral Polypes, etc. etc.

III. ECHINOZOA or ANNULOIDA (Fig. 12, C).—This third sub-kingdom possesses a double name, or rather is known under these two designations. Naturalists are by no means agreed whether or not the *Echinozoa* should be regarded as constituting a distinct morphological type or sub-kingdom; and certainly, when we consider the apparently heterogenous nature of the included forms, the objection to its constitution becomes feasible and warranted. Yet it is one thing to admit a defect, but quite another

matter to remedy or improve it; and although repeated attempts have been made to abolish the type, we have not, up to the present time, been presented with an arrangement sufficiently clear or satisfactory to warrant us in disbanding the *Annuloida*, and gathering up anew the scattered members of the group. Although, then, the *Echinozoa* may be considered by some authorities as a kind of "refuge for the destitute," in that it shelters certain forms which, apparently, would not be at home elsewhere, there are not wanting those, on the other hand, who recognise the stable nature of the type, and who claim the recognition of the sub-kingdom, on the ground that it possesses certain very definite characters of its own.

These characteristics are, firstly, the complete specialisation of the alimentary tract (*b c*) from the general or "somatic" cavity of the body (*e*); the digestive system being now complete, and shut off from communication with the body-cavity. In some *Echinozoal* forms a distinct digestive system may be wanting, but in none do we find the communication between the digestive system and body-cavity so characteristic of the *Cœlenterata*. A nervous or neural system (*g*) is developed in all, and a hæmal or blood-vascular system (*f*) is very generally present. But the character of most importance in the *Annuloida*, and which seems to link together the dissimilar forms included in the sub-kingdom, is the very general possession of a peculiar system of canals (*h*) ramifying through the body, communicating with the outer world, and serving for the transmission of water; from which latter fact the very applicable name of "water-vascular" system has been given to this arrangement. This system may be made subservient to locomotion, or may apparently be excretory in function. But its almost invariable presence, notwithstanding diversity in function, argues strongly for its recognition as a character of the group. Reproduction in the *Echinozoa* is generally of the sexual variety, although there are instances in which the process may more or less partake of the nature of an asexual act.

The disposition of the symmetrical elements in the young and in the adult stages of the more typical *Echinozoa* show a wide dissimilarity; and, indeed, partly from this feature in their development, the idea of ranking these forms as a subdivision of the *Annulose* type has, I believe, chiefly sprung. The term *Annuloida*, it may also be mentioned, has been applied to this type of structure, from the same idea of similarity to the next and higher sub-kingdom, that of the *Annulosa*, from which, however, the *Echinozoa* are to be carefully distinguished.

The class *Echinodermata*, represented by the Star-fishes and Sea-urchins, constitute the most typical group of the

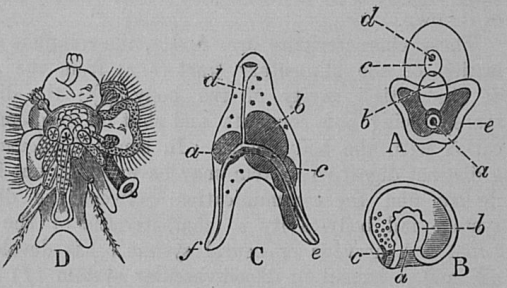

Fig. 13. Development of Echinoderm (after Müller.

A, Earliest stage of embryonic or larval form, showing *a*, mouth; *b*, stomach; *c*, intestine; *d*, anus; *e*, ciliated spheres. B, Later stage of A: *a*, mouth; *b*, intestine; *c*, ciliated bands. C, Further stage, showing larval form known as "Pluteus;" *a*, mouth; *b*, stomach; *c*, intestine; *d*, calcareous skeleton. D, Form of true embryo or "Imago" evolved from the "provisional larva."

sub-kingdom, and it is therefore in these forms that the analogies of the type are to be traced. The development of the young *Echinoderm*, therefore, presents us with a very characteristic phase in the special definition of this particular division of the sub-kingdom. The egg of the *Echinoderm* is first observed as a free and active embryo (Fig. 13), usually ovoid in shape, and propelling itself through the water by aid of the cilia, or hair-like filaments, with which its body is provided. In this state it

appears to resemble much the condition of an Infusorian animalcule, but soon the more important phases of development set in, and the cilia next present a more definite arrangement, and appear to form several transverse bands (Fig. 13, A, *e*) disposed on a body which is now bilaterally symmetrical, that is, equally disposed or arranged on each side of the mesial or middle plane. At this stage of development the body may be provided with lateral processes or appendages; and, generally, we find a calcareous or limy skeleton (Fig. 13, C, *d*) developed within the embryo form, which serves to strengthen and support the rudimentary body. And with the further development of a distinct digestive system in the larval form, the first stage in its progress towards maturity may be said to close.

The next and concluding phases of development consist in the curious production of the adult form from within the body of this embryo, or "provisional larva" (*Bipinnaria*, or *Pluteus*), as it has been called. The upper surface of the embryo now becomes involuted, or driven in upon itself, so as to assume a tubular form; and growing inwards and into the interior of the larva, this tube finally terminates to form a circular vessel, which encircles the œsophagus or gullet of the larva. Soon this rudimentary and rapidly-formed tube and its addenda become converted into the main trunks of the "ambulacral" or "water-vascular" system, and from the germinal matter or "blastema" developed around this tubular formation, the walls of the body, the characteristic skeleton of the adult, and the other systems of the fully-grown Echinoderm, are in due course formed (Fig. 13, D). The larval form itself, at the expense and from the material of which this new body has been constructed, is cast off from the new being, or its remaining parts may be employed in the further elaboration of the perfected form. The symmetry or shape of body in the adult is distinctly and characteristically "radial;" that is, the elements of its form are arranged around a common central point or axis. But, as we have noticed, the symmetry in the young and larval form is bilateral; and it

is this remarkable change of form and its analogies which have induced some observers to classify the *Echinozoa* with the *Annulosa*.

Whilst, therefore, recognising the distinctness of type in the *Echinozoa*, we will form a fuller and truer estimate of their relations if we keep in remembrance the points already stated with reference to their affinities with the higher sub-kingdom.

Table of Divisions of Echinozoa.

Class I.—*Echinodermata.*—Development of an external "test" or "shell," formed generally of calcareous matter, but sometimes of coriaceous or leathery texture; water-vascular system communicating with exterior, and generally subserving locomotion; symmetry of larva or embryo bilateral (Fig. 15), that of adult "radial." *Ex.* Echini or Sea-urchins; Star-fishes; Crinoids or Sea Lilies; Sea Cucumbers, etc.

Class II.—*Scolecida.*—No calcareous integument; water-vascular system not subserving locomotion, but in all probability excretory; hæmal system imperfect or wanting; neural system in form of one or two ganglia or "nerve-masses;" symmetry flattened, bilateral, or rounded, in some cases approaching the segmented type. *Ex.* Tapeworms; Flukes; Wheel Animalcules (Fig. 3), etc.

IV. Annulosa (*Articulata*) (Fig. 14).—In the consideration of this type of structure we are to a great extent free from the puzzling questions of affinity which beset the *Echinozoa*. The body in *Annulosa* is typically and characteristically composed of a series of joints, segments, or "somites" (Fig. 14, 1), disposed along a longitudinal axis—that is, arranged one after the other. Each somite or segment is essentially the type of that which precedes it, and the prototype of that which follows it; the "appendages" of the segments being those parts which evince wide and marked differences in function or analogy. In the *Annulosa*, then, is typically seen the arrangement known as the "vegetative or correlative repetition of parts;" an expression conveniently indicating that marked resemblance of parts in the animal economy to each other,

which is typically exemplified in the obvious repetition of form and symmetry in the parts of plants. It is needful, however, to distinguish in practice between the nature of mere "parts," so repeated, and distinct "individuals." Thus the segments of a worm repeat each other, and exemplify the expression just noticed; but this is entirely different from the repetition of "forms" in the case of any compound organism, such as a Sea-mat (Fig. 6, *b*) or Tapeworm, in which the elements repeated are true "individuals," and not mere "parts" of a single "individual."

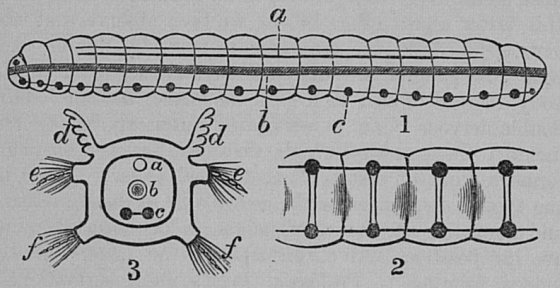

Fig. 14. Morphologigal Types.

1. Diagrammatic longitudinal section of *Annulose* animal: *a*, blood or hæmal system; *b*, digestive system; *c*, neural or nervous system. 2. Nervous system of *Annulose* animal, viewed from above, and showing the double ventral nervous chain. 3. Transverse section of *Annulose* animal: *a*, blood system; *b*, digestive system; *c*, nervous system; *d d*, gills or breathing organs; *e e* and *f f*, "oars" or locomotive organs.

The symmetry in the present instance is of the kind we term "zonal," a name applied in allusion to the evident "zones" or segments of which the body is composed. But united with the "zonal" symmetry we have also "bilateral" symmetry, since we can divide the body into an equal right and left half.

The "plan" of the structural arrangement is also very distinct. The heart (*a*) is situated dorsally—that is, on the back; whilst the nervous system (*c*) is placed on the ventral surface of the body, or nearest the ground, when

the animal moves; and between these two systems, and thus occupying an intermediate position, we find the alimentary or digestive tract (*b*). In every *Annulose* animal, then, this disposition of parts prevails, but it is certainly to the peculiar form of the nervous axis that we must look for a distinctive character. Viewed laterally, as in a vertical section of the animal (Fig. 14, 1, *c*), made lengthwise through the mesial plane, the nervous axis of the *Annulosa* would appear to consist of a single series of ganglia or nerve-knots; but when we look down upon the floor of the body from above, in an ideal section showing this latter aspect (Fig. 14, 2), we then observe that the nervous cord of the *Annulosa* is typically double, and that two ganglia are disposed in each segment of the body, instead of one, as seen in the former section. This double nervous chain is perforated anteriorly by the alimentary tract, around which, therefore, the nervous cord forms a kind of collar—"œsophageal collar." Such is the typical disposition of the neural axis in the *Annulosa;* and regarding it, the chief points to be borne in mind are its position and conformation; the latter feature, indeed, forming, to Professor Owen's mind, so marked a characteristic of the group, that he has proposed for the *Annulosa* the distinctive term of *Homogangliata*, a name denoting that the nervous system is composed of similar and regularly-disposed ganglia.

The further characters of the sub-kingdom are found in the relative position of the limbs, when these appendages are present. They are regularly disposed in pairs, and are turned towards the nervous side of the body, or that side on which the nervous axis is situated.

Table of the Divisions of ANNULOSA.

SECTION A.—*Anarthropoda—Annulosa* destitute of jointed limbs articulated to the body.

Class 1. *Gephyrea*—Spoonworms.

,, 2. *Annelida*—Earthworms, Leeches, Sandworms, etc.

SECTION B.—*Arthropoda—Annulosa* possessing jointed limbs articulated to the body.

Class 3. *Myriapoda*—Centipedes, Millepedes.
,, 4. *Insecta*—Insects, Flies, Beetles, Lice, etc.
,, 5. *Arachnida*—Spiders, Mites, Scorpions, etc.
,, 6. *Crustacea*—Lobsters, Crabs, Shrimps, Woodlice, etc.

V. Mollusca (Fig. 15).—The chief characters distinguishing the present type or sub-kingdom are found,

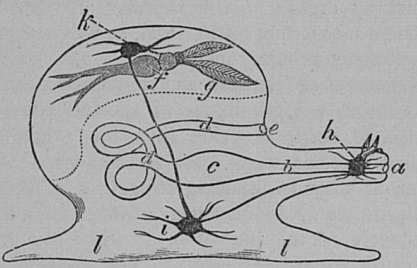

Fig. 15. Morphological Types.

Diagrammatic plan of *Mollusc*: *a*, mouth; *b*, gullet; *c*, stomach; *d d*, intestine; *e*, anus; *f*, heart; *g*, gills; *h*, "cephalic" ganglia; *i*, "pedal" ganglia; *k*, "branchial" or "parieto-splanchnic" ganglia; *l l*, foot.

firstly, in the absence of distinct segmentation and serial appendages; secondly, in the general presence of an external calcareous support or "shell;" and, thirdly, in the characteristically irregular disposition of the nervous system. Besides these principal characteristics, several points of minor importance are to be noticed.

The name Mollusca (Lat. *mollis*, soft) originated with Cuvier, and was applied to the animals included in this group, from the general *softness* of their bodies, a feature of no distinctive value, which is common, in a greater or less degree, to the other divisions of the animal series; and which, moreover, from the general possession by the *Mollusca* of characteristic *hard* parts in their shells, cannot be said to be either strictly or correctly applicable to them as a distinctive point. Still, the name has been retained, and it serves, apart from its derivation, as well as any other, to designate this large and important group of beings.

Firstly, the *Mollusca* do not exhibit any definite

segmentation or division of the body, such as we find in the *Annulosa;* and this first point will at once serve to distinguish any *Mollusc* from any ordinary *Annulose* form.

A "shell" is generally, though not always present, and this exoskeleton generally bears a definite relation to the breathing organs of the animal. The shell varies greatly in form and composition, and, as we have remarked, may be wanting in many instances.

The functions of nutrition and reproduction in *Mollusca* usually exhibit a high degree of specialisation; but it must also be borne in mind that the respiratory and circulatory systems may exist in a very rudimentary condition, or may be wanting altogether. The alimentary tract (*a b c d*) is, however, always well developed, independently of the perfection to which the hæmal or respiratory systems may attain. The digestive tract in *Mollusca* is rarely straight, as in many *Annulosa*, being usually bent upon itself (Fig. 15), so that the anal opening (*e*) is situated in proximity to the mouth (*a*). The symmetry of the Mollusc is typically of the bilateral description; the equal or bilateral halves of the body existing on each side of a median line, which, however, in the present case is slightly curved. When separate organs of locomotion are developed, they are of soft character, usually single, and placed in the middle line of the body (*l l*).

Reproduction in *Mollusca* is generally sexual, but in a few instances the asexual method, known as "gemmation," or "budding," is to be noticed. In most of the *Mollusca* the sexes are united in the same individual, but in many forms they are found distinct.

The disposition of the nervous system forms the last and most important feature to be considered in discussing the distinctive characters of the *Mollusca*. In the "plan" (Fig. 15) the neural axis (*h i k*) of the *Mollusca* is seen to be irregularly disposed over the body, and this scattered condition of the ganglia or nerve-centres has suggested to Professor Owen the term *Heterogangliata;* a name used in opposition to that of *Homogangliata*, which

latter term we have already seen to be applied to the *Annulosa*. In the typical Mollusc the nervous system consists of three chief pairs of ganglia, known respectively as the "supra-œsophageal," or "cephalic" (*h*); the "pedal" (*i*); and the "parieto-splanchnic," or "branchial" (*k*). These three great centres are connected together by nervous cords, and exist, as their respective names imply, in certain defined regions of the body. Thus the "supra-œsophageal" or "cephalic" ganglia (*h*) are situated in the region of the head; the "pedal" ganglia (*i*) in the vicinity of the "foot" or locomotive organ; and the "parieto-splanchnic," or "branchial" ganglia (*k*), in the neighbourhood of the heart (*f*), gills (*g*), and adjacent viscera. This disposition of the nervous axis constitutes, therefore, a marked diagnostic feature of the *Molluscan* type of structure.

Table of the Divisions of MOLLUSCA.

SECTION A. *Molluscoida* or *Lower Mollusca.*—Mollusca in which a single nervous ganglion, or single pair of ganglia, exists. Heart absent or rudimentary.

Class 1. *Polyzoa.*—*Ex.* Flustra, Sea-mats (Fig. 6), etc.
,, 2. *Tunicata.*—*Ex.* Sea-squirts, Salpa, etc.
,, 3. *Brachiopoda.*—*Ex.* Terebratula, Lamp-shells, etc.

SECTION B. *Mollusca Proper* or *Higher Mollusca.*—Mollusca in which three principal pairs of ganglia are present. Heart always well developed, and consisting at least of two chambers.

Class 4. *Lamellibranchiata.*—*Ex.* Oysters, Cockles, Mussels, etc.
,, 5. *Gasteropoda.*—*Ex.* Snails, Whelks, Sea-Lemons, etc.
,, 6. *Pteropoda.*—*Ex.* "Whale's-food," Clio, Hyalæa, etc.
,, 7. *Cephalopoda.*—*Ex.* Cuttle-fishes.

VERTEBRATA (Fig. 16).—The first and most distinctive character of this, the last and highest group of the animal series, is found in the possession by every vertebrate of a column or rod (*a*), generally of osseous or bony material, usually segmented, and known as the "vertebral column," "spine," or "backbone." This column—from the presence of which the sub-kingdom derives its name—we find to be typically provided with a number of upper or "dorsal" arches, and a number of lower or "ven-

tral" arches (Fig. 16), corresponding and related to the segments of which the column is composed. The segmentation of the column follows the same order and arrangement we have already observed in the body of the annulose animal as a whole. It is thus composed of a series of joints or segments arranged one after another in a longitudinal axis. The chief nervous centres (*b*) of the *Vertebrate* are contained within the bony canal formed by the upper arches of the vertebral column; whilst the ali-

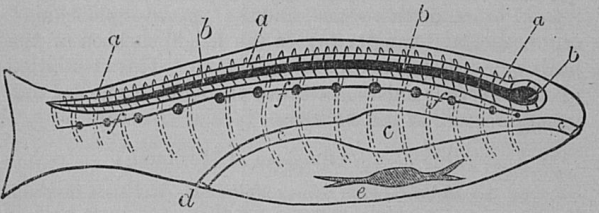

Fig. 16. Morphological Types.

Diagrammatic plan of Vertebrate type: *a a a*, Vertebral column or spine, the upper arches of which enclose the brain and spinal cord; *b b b*, "cerebro-spinal" nervous system or axis, consisting of the brain and spinal cord; *c c*, digestive or alimentary system; *d*, anus; *e*, hæmal or blood-vascular system; *f f f*, "sympathetic" or "ganglionic" nervous system. The dotted lines represent the lower or visceral arches of the vertebral column (represented in chief by the ribs), which enclose the general viscera of the body.

mentary (*c*), blood-vascular (*e*), and other systems, are enclosed by the lower or "ventral" arches. The relative position of the various systems is the reverse of that seen in the *Annulosa* and *Mollusca;* and the ideal "plan" of the vertebrate body (Fig. 16) therefore shows us the nervous axis (*b*) situated dorsally, the heart (*e*) placed ventrally, and the alimentary tract (*c*) occupying as before a central or intermediate position.

A clearer conception of this arrangement is seen in a transverse section of the *Vertebrate* body, and in its comparison (Fig. 17, B) with a similar section of the body of an *Invertebrate* animal (Fig. 17, A). Thus we find

that the *Vertebrate* body consists of two tubes — a "dorsal" (p^2) and a "ventral" tube (p^1)—lying parallel to each other. The upper or dorsal tube, formed by the spinal column and its upper arches, contains the chief nervous centres (n^2), consisting of the brain and spinal cord, and from this feature the upper tube of the *Vertebrate* has been termed the "neural tube." The lower or "ventral" tube, formed by the lower arches of the vertebral column, contains the organs pertaining to the functions of "organic life," and accordingly we find in this latter tube the heart (h) occupying a ventral position, the alimentary canal (a) in the centre, and above this latter, the nerves regulating the functions of organic life (n^1), and collectively constituting what is known as the "sympathetic" nervous system. This lower tube of the *Vertebrate* (p^1), from its containing the viscera

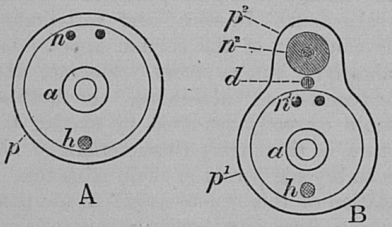

Fig. 17. Comparative Morphology of Vertebrate and Invertebrate.

A, Diagrammatic transverse section of *Invertebrate* animal: a, digestive or alimentary system; h, hæmal or blood-vascular system; n, neural or nervous system; p, walls of body. B, Similar section of *Vertebrate*: a, alimentary system; d, notochord; h, hæmal system; n^1, sympathetic nervous system; n^2, cerebro-spinal nervous system; p^1, walls of body; p^2, walls of neural or nervous canal.

generally of the body, is sometimes spoken of as the "visceral" tube, being so termed in contradistinction to the upper and "neural" tube (p^2).

The transverse section of the body of any *Invertebrate* (Fig. 17, A), on the contrary, shows us that it consists of a single tube only; and that in this single tube, which corresponds generally to the "visceral" tube of the *Verte-*

brate, all the organs of the body are contained. The "neural" tube of the *Vertebrate* (p^2) is therefore entirely unrepresented in the *Invertebrate* body, and this specialisation of the nervous centres is accordingly to be remembered as one of the most distinctive features of *Vertebrate* organisation.

The fact of every *Vertebrate* possessing, as previously stated, a column or rod, generally of bony material, and usually segmented, forms a second character of importance. But it is to be remembered, at the same time, that all vertebrates do not possess such a structure in its entirety and perfection. A few of the lower members of the sub-kingdom do not possess a vertebral column of perfect structure, but in lieu thereof they are provided with a rod-like structure, termed the "notochord," or "chorda dorsalis" (Fig. 17, B, *d*), which represents the vertebral column of higher forms in a rudimentary stage of development. In such lower vertebrate forms, then, the development of the column appears to be retarded or abortive; but, as every vertebrate animal in its early life possesses a "notochord," our first definition might be more correctly rendered by stating that this latter structure is thoroughly characteristic of all *Vertebrata* in the embryonic period of their existence.

The formation of this "notochord" in the production of the *Vertebrate* form is exceedingly interesting, from a developmental point of view. At an early stage in the progress towards maturity, the upper part of the ovum or egg becomes elevated on each side to form two parallel ridges, enclosing a groove known to embryologists as the "primitive groove." Shortly the margins of these ridges unite in the middle line to form a continuous canal, in the centre of the floor of which a rod-like body of cellular structure is developed. This rod-like body is the "notochord" (*d*), which subsequent phases of growth develop in the higher forms into the vertebral column, but which, in a few lower forms of vertebrate life, remains throughout existence in its primitive state.

The symmetry of the *Vertebrate* type corresponds in

character to that of the *Annulose* sub-kingdom. The bilateral condition and zonal arrangement are both present; the latter being typically seen in the segmented disposition of the vertebral column, and to some extent in the body as a whole also.

The vertebrate skeleton is typically *internal*, and this condition contrasts with that of the skeleton in invertebrata, in which it is external to the body. The limbs are never more than four in any *Vertebrate*, and are supported by appendicular elements of the skeleton. They are unlike the limbs of the *Annulosa* in being so disposed that they are turned away from the region of the body in which the chief centres of the nervous system are placed.

The various systems of the body partake of the high degree of specialisation consistent with the advanced character of the morphological type. It is worthy of notice, as a distinctive feature, and one which contrasts with the analogous arrangement in the *Invertebrata*, that the œsophagus or gullet of the *Vertebrata* does not perforate the nervous centres, but deflects from the course of the nervous axis, and opens upon the side of the body opposite to the neural system. The jaws of *Vertebrates*, when present, are always parts of the head, and are never represented, as in *Invertebrates*, by modified limbs, or by hard structures developed in the lining membrane of the alimentary or digestive tract. The heart, in every instance except one, is single, and there exists in all cases a closed system of blood-vessels; this arrangement differing entirely from the imperfect circulation of many *Invertebrate* forms. A certain portion of the impure or venous blood in the *Vertebrata* is collected into a large venous trunk, the "portal" vein, by which it is sent to the liver; and from this supply of blood the bile is elaborated by the latter organ. Such an arrangement is purely characteristic of *Vertebrate* forms.

Reproduction in *Vertebrates* takes place only by sexual methods; and the sexes are invariably situated in different individuals.

Lastly, in the development of the *Vertebrate* ovum, we

can trace many points of peculiar and distinctive interest. We have already seen how the characteristic features of the *Vertebrate* type, in the formation of the chief nervous centres, and in the development of the notochord, are discernible at an early period in the life of the embryo. Another and final feature of developmental interest, consists in the presence, in the embryonic stages of every *Vertebrate*, of a series of openings or clefts, borne on the sides of the mouth, and known as the "visceral clefts" or "arches." These, in the case of fishes and some amphibia, retain throughout life somewhat of their embryonic nature, and bear the "branchiæ" or "gills;" whilst in all other vertebrates they become obliterated, and thus subserve no function or purpose in the life of these higher forms. Their universal occurrence, as embryonic structures in all *Vertebrata* thus forms a feature worthy of mention in defining the type. Various systems of classification of this important sub-kingdom have been proposed, but it may suffice, in the present instance, to simply enumerate the classes into which the Vertebrata, by common consent, are divided.

Table of the Divisions of VERTEBRATA.

CLASS 1. *Pisces* or Fishes.	Breathe by gills alone; or by gills in combination with lungs.	
„ 2. *Amphibia*—Frogs, etc.		
„ 3. *Reptila*—Reptiles.	Never breathe by gills, but by lungs exclusively.	
„ 4. *Aves*—Birds.		
„ 5. *Mammalia*—Mammals.		

It may be further remarked that the enumeration of the characters of these great "Morphological Types" will, if correctly appreciated, aid us in a great degree to the proper understanding of many important and subsequent questions, but chiefly that of the modern system of zoological classification, in which, as already remarked, these morphological types, under the name of "sub-kingdoms," figure as the great primary groups into which the entire animal series is divided.