Comparative Anatomy

AND

Physiology.

BY

F. JEFFREY BELL, M.A.,

PROFESSOR OF COMPARATIVE ANATOMY AT KING'S COLLEGE.

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To

SEPTIMUS W. SIBLEY, F.R.C.S.,

AS A LITTLE TOKEN OF RESPECT

FOR THE

SKILL AND SYMPATHY WITH WHICH HE EXERCISES

HIS BENEFICENT ART.

PREFACE.

THE reader who is sufficiently acquainted with the progress in vertebrate physiology during the last phase of physiological methods, and who knows how scattered and incomplete are the investigations which have been made by the same kind of physical and chemical inquiries on invertebrate animals, will not expect to find in the present volume any complete statement of the physiology of animals, in the sense in which that term is now used. Such observations as have been made without especial reference to the vital processes of man are, for the most part, very valuable and suggestive; but the time to write a text-book of Comparative Physiology, as we now understand it, has not yet arrived.

All that I have attempted to do in this little book has been to illustrate the details of structure by a notice of such experimental inquiries as I have convinced myself, or have adequate reason to believe, are, in their broad outlines, correctly stated. I have much more attempted to make use of what were long since called the experiments that Nature makes for us, by referring to, sometimes perhaps insisting on, the different methods by which similar results are attained by different animals. That which I have most constantly kept before myself, and which I hope the student will faithfully bear in mind, is, that there has been an evolution of organs as well as of animals, and that he who desires to understand the most complicated organs must first know the structure of such as are more simply constituted.

In pursuit of this object, I have written about organs rather than about groups of animals; but I have added an index in which the various parts of an animal are collected under the head of its name; so that the student who desires to use this manual as a zoological text-book will have no difficulty in selecting the portions of the chapters which bear on a particular form or set of forms.

I have departed a little from the ordinary method of writing a handbook, in somewhat plentifully interspersing the names of my authorities for various statements. I have done this, not only because it recommends itself to my sense of justice, but because zoological science is just now advancing so rapidly that many observations and suggestions have to be incorporated, even in a text-book, before they become the general property of zoological workers. My indebtedness to the personal teaching and the published writings of Professor Ray Lankester must be by no means thought to be limited to the statements with which his name will be found to be connected; indeed, I owe him more than I can well express.

I have been careful to acknowledge the source whence the illustrations are taken, and I have to return my thanks to the Publication Committee of the Zoological Society; to Professor Flower, who only added one more to a number of acts of personal kindness when he generously put at my disposal all the wood-blocks which were in his own possession; and to those other friends who have allowed me to copy figures from their works.

As this manual is written on lines that are rarely followed, I shall be greatly obliged for any suggestions as to its improvement, or for corrections of any errors which may have found their way into it.

F. JEFFREY BELL.

King's College, May, 1885.

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Comparative Anatomy and Physiology.

CHAPTER I.

INTRODUCTORY.

Comparative anatomy is the science of the structure of animals, considered in their relation to one another; **comparative physiology** deals with the functions of the parts of which these animals are made up, and, by examining different forms that present various kinds of activities, it throws light on the essential properties of living matter.

The study of animals is but a part of the wider science of the study of organised matter generally, the science of **biology,** which takes plants as well as animals for the objects of its investigations. Under the head of biological studies we have, therefore, to group (*a*) those which regard organisms as working machines, capable of performing various functions; these studies are physiological, whether animals or plants be separately or simultaneously examined; (*b*) in the second place, the parts of which the organism is made up may be investigated, and our studies are then said to be anatomical, if we concern ourselves with isolated types, as does the student of human anatomy; or they are morphological, when we compare organisms and their parts one with another, and try to draw out the significance of isolated facts, and to learn their bearing on the general scheme of the organisation of living matter.

The present work is concerned only with Animals; but, as there is a fundamental resemblance between Plants and Animals, it is in the first place necessary to enquire into the characters and modes of activity of living matter, pure and simple, without any question as to whether it be animal or vegetable.

LIVING MATTER.

Animals and plants have at least this in common that they are both fashioned out of a material which, in all its essential characters, is common to them both; and, whether one would be a zoologist, or student of animals, or a botanist, or student of plants, it is, in the very first place, necessary that he should have some clear and exact comprehension of what are the characters and what are the modes of action of that primary fashioning substance which forms the material basis of living creatures, and which is known as **protoplasm.** The fact that the sciences of zoology and botany have to do with this "physical basis" of living matter separates and distinguishes them at once from such studies as chemistry or physics, with which the phenomena of life have no necessary connection.

Living is distinguished from **not-living** matter by several important and easily recognisable characters. It would seem to have a fundamental and characteristic composition; it has the power of continuing to exist by taking into (**nutrition**), and making part of itself (**assimilation**) other living or even not-living matter. Nutrition and assimilation lead to **growth,** and this growth is succeeded by a stage in which the additional material obtained is used for the purposes of **reproduction.** After a time a living organism may be seen to be unable to withstand the action of the surrounding forces in the midst of which it has lived, grown, and reproduced itself; in other words, its activity diminishes and diminishes, until at last it **dies.** From this **dead** matter, living material can never, by any process now known to us, be produced; for, so far as we know, living matter can only proceed from other living matter.

As the chemist is only able to acquire definite information with regard to the chemical composition of living matter by the use of certain treatments which deprive it of life, we cannot speak with certainty of more than the broad outlines of its composition; but this, at least, may be said: in living matter (**protoplasm**), the four chemical elements, oxygen, hydrogen, nitrogen, and carbon, are always found, and with them there would seem also to be associated small quantities of sulphur and phosphorus. It is possible, if not certain, that protoplasm is a compound of a number of the so-called proteid bodies, and it is quite certain that what chemists call its "atomic composition" is very high. One of the most complex bodies known to us is that constituent of the brain which is called **protagon**; and its "atomic composition" has been determined to be $C_{160}H_{308}N_5PO_{35}$, or no less than 509 atoms. When such a body is active, fresh chemical changes are always taking place within it; it is in a condition of unstable equilibrium; the result of such change, so far as it affects the living matter, is **loss** or **waste**; in addition to this, living matter is always taking up fresh oxygen, and forming carbonic acid, of which it has to free itself. These activities combined require, as may be supposed, the addition of fresh material from without; that is to say, living matter demands food. The food so taken in may or may not be similar in composition to the organism itself; but, as the living creature has wasted through all its parts, the fresh material has not merely to be taken in, it has also to be assimilated. When a crystal, placed in a solution of its own material, grows, it does so by merely laying on the fresh molecules outside those already formed; protoplasm, on the other hand, makes the fresh food, which may or may not, indeed need not, have the same composition as itself, an essential part and parcel of itself.

In the next place we observe, that while a crystal under the conditions just now mentioned will grow so long as it is supplied with matter of similar chemical constitution, living matter only grows when assimilation goes on at a quicker rate than destruction or waste. Save for the difficulties of experimenting, there is no reason why all the sulphate of copper in the world should not (α) be brought into one huge crystal, and (β) so remain. It is not so with living matter; for every organism there appears to be a limit of growth, and when that is reached, all the succeeding matter assimilated goes for a different purpose. The organism, ceasing to grow, begins to reproduce its kind, and, in the very simplest cases, produces an individual exactly similar to itself. This act of reproduction appears to be, next to sustentation, the primary work of every organism, and when that is completed, we often observe that the parent organism begins to lose its activity; it becomes the prey of other living organisms; or, undergoing gradual decay, the complex mass of albuminous matter, which we call protoplasm, and associate with life, falls away into constituent molecules of a less high degree of chemical complexity.

Assimilation, growth, reproduction, death, are, as here explained, four phases in the history of living matter which at once and sharply distinguish it from crystalline or other dead material.

Nor is this all; if we set one crystal against another of similar composition, or if we try to rouse or stimulate a crystal, we get no response. With living matter the case is very different; roused either by some apparent friend or enemy in the water, or by a touch from our needle, as we observe it under the microscope, a mass of living matter will be found to be **irritable.** In consequence of this **irritability** it undergoes some change converting latent into actual energy, and this is most frequently and most easily seen to be some change in space, or in the relations of its parts; these are due to what is known as the **contractility** of living matter. In other cases, the production of heat, light, or electricity, is the expression of irritability.

We have next to observe, that within the area of any given mass of protoplasm, there may be movements of its parts; some of the granules seem to **stream** in a more or less regular course between those on either side of them, in a way which can best be understood by supposing the observer to be raised above and to be able to note the movements of a great crowd of passengers in a busy street; some move faster than and overtake others, some collect into more or less small crowds; others, having moved onward for a certain distance, turn aside or turn back. This streaming movement of protoplasm is highly characteristic, and affords a proof that the problem of the motile activity of protoplasm can only be explained by the study of the parts of which it is made up.

Lastly, thin layers of non-granular protoplasm are sometimes to be observed **gliding** over firm bodies; by these means the whole mass is enabled to progress in a forward direction.

The study of streaming movements shows us that the constituent particles do not move around any fixed point, but freely as the particles of a fluid substance. So far as we can see, these movements are not the result of any external cause; did we choose to allow that a simple mass of protoplasm had a "will," we might well call them "spontaneous" or "voluntary;"

without going so far, we must allow that they appear to be due to the protoplasm itself; they are self-moved or **automatic.**

Living matter, then, is irritable and automatic; irritability finds expression in contractility, or in the production of such forces as heat, light, or electricity.

With regard to its general **physical** and **chemical** characters, we have to note that it is possessed of great cohesive powers, and yet is very extensile; it does not mix with water, but it swells by imbibition; it may expel the contained fluid in the form of rounded vacuoles, and bubbles of gas are sometimes apparent in it. It is ordinarily colourless, and refracts light more strongly than water; it is in most, and probably in all cases, slightly alkaline in reaction.

Before we leave the general consideration of protoplasm, we must point out two foreign elements which have to be considered. The first of these is the presence in protoplasm, as we ordinarily observe it, of various more simple chemical compounds, which have the form of granules; these, which may be fatty or starchy bodies, are conveniently grouped together under the head of **metaplasm;** they may be regarded as owing their origin to the changes that are constantly taking place in the molecular constitution of the protoplasm, or, in other words, as waste products not yet eliminated.

The second is a general motion of a protoplasmic mass, especially when of particularly small size (*e.g.* bacteria); this movement of the body as a whole is not a vital, but a purely physical phenomenon, as may be demonstrated by the simple experiment of rubbing up a little gamboge in a drop of water, when exactly the same movement is to be observed. This approximation and separation of small particles is a phenomenon which has attracted the attention of the physicist, by whom it must be explained; it was, however, first observed by an eminent botanist, and is consequently known as the **Brownian** movement.

The term **cell** is not unfrequently applied to every separate mass of living matter, but, in consequence of the associations connected with this term, it is better to make use of the more elaborate though perhaps more intelligible nomenclature which enables us to distinguish between the different characters of "elementary organisms." When attention was first directed to these objects, the botanist observed that in each mass of protoplasm there was a portion which, by various characters, could be easily distinguished from the rest, and which might be very appropriately spoken of as the **nucleus**; in addition to this, he saw that the outer portion of the protoplasm was enclosed as in a wall; he spoke, therefore, of the whole as a **cell**, with a cell wall, and a contained nucleus.

Later on it was found that the protoplasm (or "sarcode," as it was originally called) of animals was not to be distinguished from that of plants, and it was then also seen that it was only in very rare cases that this animal protoplasm was enclosed in a cell wall. Thereby the very first conception of a cell was destroyed, but the name was still retained as a convenient term.

Still later researches revealed the at first astonishing fact that organisms could and did exist in which that specially modified portion of the protoplasm which had been called the "nucleus" was, to all appearance, altogether absent; some naturalists, and especially some physiologists, now regard the nucleus as no essential part of the cell. On the other hand, it seems better to recognise in our nomenclature the present conditions of our knowledge, and to use for the "elementary organism" some other definite term than that around which so many battles have been fought, and with which, perhaps, no few superstitions are or have been connected.

We will, therefore, follow those who have agreed to the suggestion of Prof. Haeckel, and will use for the elementary organism, whether or no provided with a nucleus, the useful and suggestive term of **plastid.** This **plastid,** or unit of organic structure, is composed of protoplasm; it may be without a nucleus, when it is a **cytod** (or cell-like body), or it may have within it a denser mass, which is very feebly, if at all, contractile, the **nucleus;** in which case it is a **cell.** This nucleus is ordinarily provided with one or more smaller **nucleoli,** and, possibly, always has a distinct investing membrane. It would appear to have a special chemical composition, inasmuch as while a cell when treated with a ten per cent. salt solution leaves a precipitate, no such precipitate is stated to be found when a cytod is subjected to the same reagent. The body so precipitated has been called nuclein.

Protoplasm, then, is presented to us in the form of plastids, and these plastids may either be without (cytods) or have (cells) distinct nuclei. All organisms are composed of one or more cells, or, in other words, are either unicellular or multicellular. The former, as much as the latter, are capable of exhibiting all the essential phenomena of life.

TISSUES AND ORGANS.

When we examine the different stages in the history of a developing animal, or compare a series which commences with low and passes through more highly developed forms, we find a gradual increase in the complexity of the parts; of this we have already had an example in comparing the cytod with the cell, and we shall observe it in every chapter of this work. This increase in complexity is termed the process of **differentiation.**

In making a general survey of animals we find that the lowest consist only of simple cells ; later on, the cells are found not to live an independent existence, but to be associated one with another, and different groups of cells are seen to be differentiated in various ways. The result of this is that sets of cells come to have different characters (some are contractile, others irritable, and so on), and these different sets are what are known as **tissues;** secondly, we observe that these tissues become connected with one another in different proportions and relations, so as to give rise to those parts of the adult which take on particular duties, and are known as **organs.**

Looked at in a general way, and without taking any notice of exceptional cases, we observe that there are tissues in an animal which are not found in a plant; these, which are distinguished as the **animal tissues,** are such as have a relation to movement or sensation; in other words, the muscles and nerves are animal tissues. On the other hand, plants preserve, protect, and sustain themselves, and the corresponding tissues in animals are always spoken of as the **vegetative;** of these we may find convenient examples in that outer layer of the body which is spoken of as epithelium, or that supporting tissue which is known as bone.

The classification of organs is a little more complex, but it will be convenient to give it now, so that time and space may be saved in the future.

In the first place it is clear that the vegetative functions fall under three great heads; an animal has to care for itself, to adapt itself to or move through its surroundings, and to reproduce its kind. And, in the second place, it is just as obvious that it has to perceive what is going on around it, and to act accordingly. We have, then :

(1) Organs of internal relations.
  i. **Protective.**—Examples: Skin, shell.
  ii. **Nutritive.**—Examples: Digestive tract (nutrient); heart and blood-vessels (circulatory).
  iii. **Purifying.**—Gills, lungs (carbonic acid); kidneys (nitrogenous products).

(2) Organs of external relations.
  iv. **Locomotor.**—Limbs, etc. (compounded of skeletal and muscular tissues).
  v. **Prehensile.**—Limbs, etc. (compounded of skeletal and muscular tissues).
  vi. **Offensive.**—Teeth, claws, electrical, odorous organs.

(3) **Reproductive.**
  (α) Germ-producing glands: testes, ovaries, which are **essential.**
  (β) Copulatory: penes, etc., which are **accessory.**

(4) **Sensory.**
  (α) Organs which **receive** impressions; eye, ear, etc., brain.
  (β) Organs which **stimulate** other organs; brain.

METHODS OF COMPARISON.

When an anatomist has acquired a positive knowledge of a certain number of selected forms of life, he proceeds to convert his empirical acquaintance with facts into science by reasoning upon the information which he has acquired. In this operation he makes great use of the fertile method of comparison, remembering the words of Buffon, "*Ce n'est qu'en comparant que nous pouvons juger.*" Like things, however, must be compared with like, or confusion will inevitably result. We must, therefore, lay down certain rules to guide us in these kinds of enquiries, for, though no one would attempt to compare a heart with a lung, many would, at first, more willingly compare the leg of a man with that of a cockroach, than the fin of a perch with the wing of the sparrow; yet the latter is the more justifiable proceeding.

The reason for this is plain, the moment we clearly understand what object the comparative anatomist has before him; it is that of coming to some general conclusions as to *identity or community of structure;* for this purpose, then, he is not to compare parts that have the same function, but those that are formed in the same kind of way. The physiologist, on the other hand, looking at organs as parts of a machine, examines together those that do the same thing. When we compare parts morphologically, we must not be content merely with an **analogy** between them, we must be careful that there is a **homology** or real resemblance.

The first criterion of homological parts is their development from similar embryonic structures; such are the wing of a bird and the leg of a horse. But a further question now arises; why have these wings and legs, which in their completed condition are so different from one another, a similar structure in the embryo? The answer to this is given by the **doctrine** of **descent,** which supposes that the bird and the horse had in the past a common ancestor, provided with limbs simpler in structure than those of either bird or horse, but having essentially that which they have now, or which they have had, and from which they are both derived; a true and complete homology of parts is, then, only to be found between animals which have had a common ancestor provided with the part to be compared. This complete homology may be conveniently spoken of as **homogeny** (Ray Lankester).

It is very necessary to have before the mind this idea of community of descent, because we shall constantly meet with cases in which, with a very close resemblance in structure and mode of development, there is not a complete identity in descent. For example, all mammals and all birds are provided with four cavities in their hearts: two auricles and two ventricles; but it is certain that, whatever was the animal that was the nearest common ancestor to the two, it had only one ventricle. The right and left ventricles of the hearts of birds and mammals are, then, not homologous in the sense of being homogenetic; they have been acquired independently by the two groups, in consequence of certain physiological needs; they are the result of similar modifying forces, and are **homoplastic,** but not homogenetic parts.

DEVELOPMENT.

The last point to which the student must be introduced is one of the very greatest importance. If we study the animal kingdom throughout, we find that, starting from the simplest mass of protoplasm, we are gradually led to the complex and elaborate structural and functional arrangements which are found in so highly organised an animal as man himself. If, on the other hand, we study the developmental history of a highly organised form, we find that it starts from a simple mass of protoplasm, the egg, or **ovum,** as this plastid is called; this cell gradually becomes more and more elaborated, and takes on the more complex arrangement which may be seen in its parent; we observe, that is, that not only are there a number of stages in the different representatives of the animal world, but that there are also a number of stages in the structural history of every individual; and we may go yet a step farther, and say that in a broad and general way there is a complete parallelism between the two.

The results of the investigations and considerations which flow from a study of the facts here indicated are best expressed in an aphorism, which may at once be laid to heart, and which will be abundantly proved by a study of development and comparative anatomy:

"The history of the individual is a compressed epitome of the history of the race."

Those, therefore, who desire to obtain a complete knowledge of animals or, indeed, of any one animal, must not be contented with an account of the anatomy of the adult; they must direct their attention also to its development, and become the students of **Embryology,** while they must no less take care to study the history of the animal, or of its allies, in the past ages of the world, or to know something of its **Palæontology.**

These two branches, **Embryology** and **Palæontology,** are of the greatest assistance in an endeavour to obtain some clear idea of the morphology of animals; but a weapon no less sure and no less important is that of comparison, by means of which similar parts in different organisms are studied and explained; no better aid to safe judgment can be afforded, and it must be used unceasingly and unsparingly.

EVOLUTION.

The great maze and mass of facts which are found in works on zoology or comparative anatomy are hardly to be held together without the bond of philosophy; the grouping of facts, and, still more, the grouping of animals, must be always more or less unintelligent, mechanical, and artificial, unless we make some use of some kind of explanation. That which we shall use here will be founded on the belief that there is a blood relationship, or relationship by descent and inheritance, between every member of the animal kingdom; and that, were it possible to know all the facts, we could make a genealogical tree for animals, which should be as exact and definite as the family tree which is drawn up by the genealogist or the herald. That division of biology which busies itself with genealogical problems is known as **Phylogeny.**

All the steps in the differentiation and elaboration of organised beings are examples of that process of **evolution,** which, when based on a belief in the existence of a blood relationship between animals, is known as the doctrine of descent. In an attempt to understand how this has worked, we make reference to two different series of facts. We have, in the first place, to make certain generalisations as to the way in which the differences have been brought about, and we have, in the second, to consider what are the essential properties of living matter which may be regarded as the determining factors in the evolution of organised material.

The generalisations made from a number of observed facts may, if this definition be borne in mind, be called the laws of evolution; they have been thus enunciated by Professor Huxley :

(1) There has been an excess of development of some parts in relation to others.

(2) Certain parts have undergone complete or partial suppression.

(3) Certain parts, which were originally distinct, have coalesced.

Let us apply these laws to a concrete example, and select for study the fore-foot of a camel. In the more primitive mammalia there were five fingers or digits, each connected by a metacarpal or palm bone with the wrist, and these five sets of digits and metacarpals were of subequal size. In the hoofed group of animals the first of these, or thumb, disappeared, as in the case of the modern pig; the two that were now outermost, the second and fifth, became smaller and smaller, as in the sheep or deer, and finally, as in the camel, disappeared altogether. Here we have various stages of law 2. This loss of the outer was accompanied by an increase in the size of the median digits and metacarpals (law 1), and in the more or less complete fusion of the third and fourth metacarpals one with the other (law 3); the result of this last process being the formation of a bone which at its lower end only gives any obvious indication of its primitively double nature.

The characteristics of protoplasm which appear to be the determining factors of evolution, are (1) its power of producing an organism like to itself; and (2) the fact that no child or parent, or any two children, are exactly similar one to another. The first of these principles is known as that of **heredity,** the second as that of **variability.** It is obvious that the second principle only comes into action because of the differences in the surroundings of every individual plastid; the greater the homogeneity of the surroundings, the greater the likenesses between the plastids. The law of heredity may consequently be compared to the first law of motion (Gasquet).

Organisms, therefore, tend to resemble their parents, but, being more or less differently affected by surrounding media and objects, diverge more or less from the parent stock; the greater the differences in environment, the greater the differences between parent and child. This is a fact so well known to us all that we need not enlarge upon it here.

ANIMALS AND PLANTS.

While the conviction that there is an essential unity between animals and plants may be taken as one of the most important results of modern biology, we have to note that along the two lines of organisation the constituent protoplasm has, on the whole, developed special characteristics. In other words, we are not able always to say definitely whether a given unicellular organism is an animal or a plant; but we can always with certainty point to the differences which distinguish a rose from a bee.

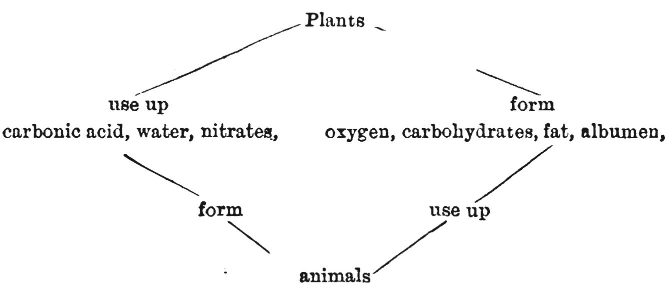
Thus the form (1) of a plant is diffuse and arborescent, that of an animal oblong and rounded. A plant lives on (2) carbonic acid and mineral salts, but an animal requires albuminoid foods. These foods are in the plant taken in (3) by the porous tissues, and there is no distinct mouth as there is in all but the lowest, and in the majority of parasitic animals. The secretions (4) of a plant are non-nitrogenous, while some of the waste products of an animal always contain nitrogen. In their habits (5) we find that plants are fixed, and animals locomotive. And, lastly, (6) as to the characters of their cells, we find that plants have a cell wall formed of that ternary compound which is known as cellulose, while the wall of an animal cell, when present, is derived directly from the cell protoplasm.

To nearly all the statements now made an exception may be found: thus (1) cacti and fungi are certainly not arborescent or diffuse, while polyps as certainly are. (2) Fungi appear to require some more complex compound than merely carbonic acid and mineral salts, but such a body as ammonium tartrate will give the nourishment required; every animal known to us requires albuminoid food, and dies when deprived of it. (4) It is quite true that plants do not give off nitrogenous excreta; but their protoplasm, it must always be remembered, is capable of forming them; on the other hand, all the excreta of an animal are not nitrogenous; Ascidians (and, if they are truly animals, some of the Cilio-flagellata) form cellulose. The latter and some low worms have been observed to form starch, and sugar is a ternary compound formed by various animals. The well-known Volvox offers (5) an exception to the statement that plants are fixed, and polyps and, to a large extent, stalked Echinoderms, to the statement that animals are locomotive. Lastly, some of the lowest plants, such as Myxomycetes, have their protoplasm naked, while the just-mentioned

Cilio-flagellata have cellulose in their cell-walls. and the so-called matrix of cartilage cells does not appear to be directly formed from the cells themselves.

This enumeration of differences or resemblances is, after all, unsatisfactory, and will, with the progress of knowledge, come, no doubt, to be regarded as misleading; for the present, it will not fail in its object of impressing on the student the broad and general characteristics of animals and plants as we now know them; but there must be added to it a reminder that among the higher members of the Droseraceæ we find plants (α) whose leaves have in some forms the power of movement when excited; (β) the glands of their leaves are able both to digest and to absorb animal matters; and (γ) the normal electrical current is, when these leaves are irritated, disturbed in the same manner as is that of a contracting animal muscle.

The general relation of animals to plants is well shown in the following table (Brass):



The fact that, in sunlight, green plants (that is, plants containing chlorophyll) give off oxygen has led some to think that plants take in carbonic acid and exhale oxygen; but plants as much as animals give off carbonic acid as a waste product. If or when an animal contains chlorophyll grains, it as much as a plant will give off oxygen under the influence of sunlight.

CHAPTER II.

AMŒBA.

It has been wisely said that "the highest laws of our science are expressed in the simplest terms in the lives of the lowest orders of creation" (Paget); and it will be well, therefore, to commence our studies with a close investigation into the characters of one of the simplest of living animals.

The word **Amœba** is a generic term,* which is applied to a number of forms, which have in common the following characters; they are more or less minute specks of nucleated protoplasm, without any wall or membrane limiting their surface, and they are capable of pushing out processes of their body substance from any part or point of it. They are sometimes as much as one-hundredth of an inch in diameter, but they in all cases require the assistance of a microscope of high powers for their satisfactory study.

If we place one on a glass slide, and, after allowing it to become used to its new position, examine it under the microscope, we shall at once see how appropriate is the name that has been given it. Its form is never constant for more than a few moments together, as we can best demonstrate by making a sketch of its shape once every minute for some five or six times.

These changes in form are, we know, expressions of the irritability and contractility of the protoplasm.

* The possibility that a number of so-called Amœbæ are stages in the life-history of animals or plants does not affect the question here dealt with.

Looked at more closely, we see in it evidences of differentiation of structure; the mass, small as it is, is not homogeneous; the outer portion is denser and

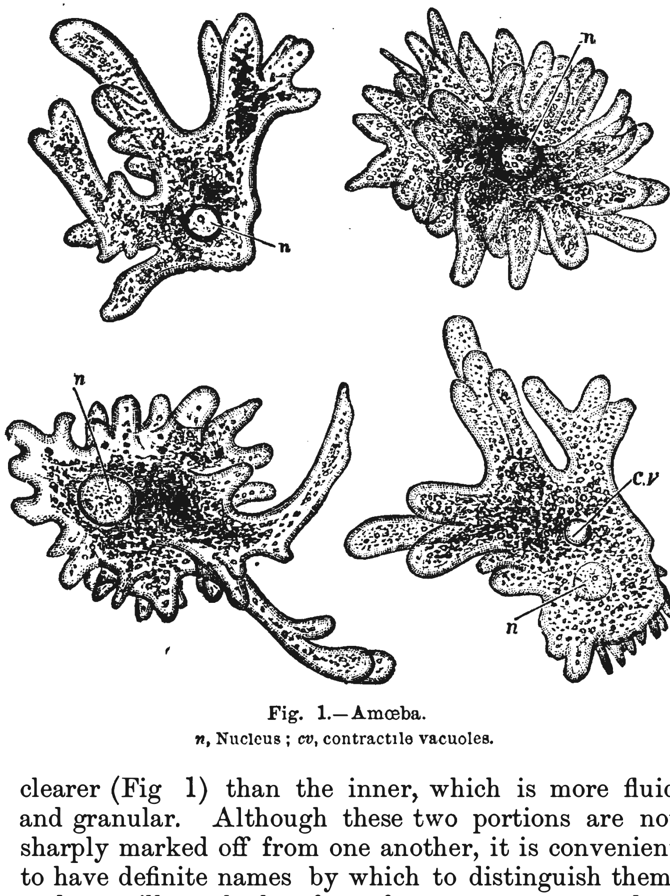


Fig. 1.—Amœba.
n, Nucleus ; *cv*, contractile vacuoles.

clearer (Fig 1) than the inner, which is more fluid and granular. Although these two portions are not sharply marked off from one another, it is convenient to have definite names by which to distinguish them, and we will speak therefore of an **ectosarc,** and an **endosarc.** Within the endosarc we see a disk-shaped or rounded body which retains its form, while the protoplasm around it is changing; this is the **nucleus** (*n*), and within it is a smaller body, the little nucleus, or **nucleolus.** In the ectosarc we have to observe a space which opens slowly, and contracts rapidly; its power of contraction may be seen to be independent of that of the general mass of protoplasm. This space (the **contractile vacuole**, *cv*) appears, though we cannot speak with certainty, to be a kind of pump, whereby water is taken into and forced out of the body; the water that enters must bring with it a certain quantity of oxygen, which is a prime necessity of every living organism, whether it be plant or animal; while the water that is forced out of the body must carry with it a certain quantity of those waste products which always appear when a living body is in active function.

The contractile vacuole, then, would appear to effect for the amœba the two processes of respiration and of purification, which, in higher animals, are performed by definite organs.

It will at once be noticed that there is no special point by which food enters, or what is useless in that food escapes from the amœba; in other words, there is neither mouth nor anus. But it will almost as soon be seen that this naked cell has no need of either the one or the other; it flows around the food it needs, and it flows away from the waste or useless matter which is of no further use to it.

Just as there is no special inlet for the food, so there is no part of the cell which can be said to be especially digestive in function. We can best see what happens to the food when it is a green-coloured plant; when such is under observation we find that it gradually breaks up within the amœba, that it gradually loses its green colour, and finally disappears; if it be a diatom that has been flowed around, we may observe in time that the undigested case will be left behind. The cell, then, of which the amœba consists, is capable of taking in food, and of making it part of itself; it can, in fine, effect all the operations of nutrition.

The flowing around food is only an expression of that general locomotor activity of the amœba which finds a more general expression in those remarkable changes in form to which we have already directed attention. These, when studied in detail, are found to be effected in the following fashion. At some point of the body where the contour is smooth and rounded a little knob of ectosarc may be seen to be protruded, and to widen out as it increases in size; the cavity in its interior which is thus formed becomes filled with endosarc which flows into it. The protrusion is at first broad or lobate, and it may so remain; or it may increase in length and diminish in proportionate breadth, or it may even become branched at its free extremity. Such an out-pushing of the substance of the naked cell is spoken of as a **pseudopodium** (false foot). When, as often happens, several small pseudopodia, or one or a few of large size are given off close to one another, and if the pseudopodia are not at the same time protruded from the opposite surface of the cell, then the whole mass follows the pseudopodia, and there is a general movement of the amœba; at such a time we can distinguish an anterior from a posterior end.

The amœba, then, feeds, grows, and moves about, takes in oxygenated water, and gets rid of waste material; exhibits, in fine, all the essential phenomena of internal and external relation; it does not exhibit anything more than a general irritability, but as it does answer to stimuli from without, it presents us with a copy, as it were, of the changes that occur in ourselves when we are acted on by external stimuli. It performs all the actions that are essential to our idea of an individual living for itself. But it does more than this; it performs also the function that is necessary for the continuance of the species of which it is a representative. It reproduces itself.

In the simplest case the act of reproduction is effected thus; the nucleus elongates, becomes constricted in its middle, and divides into two. As this division is being effected the surrounding protoplasm becomes divided into two masses, each of which accompanies one half of the nucleus. As a result of this process we have two individuals where before we had one, and they differ only from the amœba which we have been previously studying by their smaller size; as our first amœba has altogether disappeared, it is, to all practical purposes, dead; and we have, then, in this, the simplest condition of reproduction, the death of the parent absolutely contemporaneous with the appearance of a new generation. This process of reproduction is that which is known as **fission.**

Another method is also observed in the amœba, which may be regarded as a modification of that of fission. A small portion (bud) of non-nucleated protoplasm is gradually separated off from the rest of the mass; this increases in size, and develops within itself a new nucleus, so that it becomes exactly similar to its parent, which, in this case, continues to exist. Here we have reproduction effected by budding, or **gemmation.**

Notwithstanding all the functions performed by this minute mass of protoplasm, it will be observed that there is nothing in the cell to which we could correctly give the name of an organ. We are in the presence of life, but hardly of organisation.

CHAPTER III.

THE GENERAL STRUCTURE OF ANIMALS.

BEFORE proceeding to a comparative account of the structure and functions of the organs of different animals, it will be necessary to introduce the student to the broader characteristics of the groups into which the animal kingdom has been divided. What follows in this chapter is to be regarded as having that aim alone; it is in no way to be looked upon either as a classification of animals, or even as an introduction to it, and it is to be used rather as a kind of guide to the relative position of any animal that may be mentioned in the succeeding chapters. So far as is possible in the necessities of the case, it has been so prepared as to hinder rather than to aid the student in any attempt to commit to memory a system of classification; for it is certain that there is nothing less fruitful in good result than a parrot-like acquaintance with what is only a compressed epitome of the more certain results of zoological enquiries, but which, it is to be remembered, may at any time be profoundly modified by further investigation. What is called a classification of the animal kingdom is nothing more or less than a précis of our knowledge at a given moment, and, at its best, can never be more than relatively correct.

On the other hand, the sketch that follows may be of use as indicating the general course of development, taken along different lines by different kinds of animals

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The simplest animals essentially resemble an

Amœba in this particular, that, for the whole period of their lives, all the functions of the organism are performed by a **single cell;** and, even where cells remain collected into a colony, each individual member of that colony performs all its own duties, and affords no assistance to the rest; there is no division of labour.

In the higher animals a very different phenomenon is seen; here again the whole organism is, indeed, composed of cells or cell-derivates; but, howsoever complex it may become, it starts always on the cycle of its existence under the form of a single cell. This cell, which is known as the **ovum** or egg-cell, undergoes a series of divisions by means of which, two, four, eight . . . . cells are produced, and these become arranged in definite fashion, and take on more or less well-defined functions. Here, then, different parts of the organism have different duties, or, in other words, there is **division** of **labour.**

The first or lower group of organisms are associated together as the **Protozoa;** the second, or those that come after them, form the division of the **Metazoa.** Did we desire to use less objective terms, we might adopt for these groups the corresponding terms of **Cytozoa** and **Histozoa** (Maupas), which conveniently direct attention to the essential difference in the **cells** of the protozoan, and the **tissues** of the metazoan organism.

In attempting to arrange either of these divisions, we are met at once by the fact that the changes which have taken place in organisms have been in two lines or directions; there has been **progress,** and there has been **degeneration.** The former we shall find to be more intimately associated with a free and active life, and a ready power of adaptation to changed circumstances; the latter to a fixed and often to a parasitic mode of existence.

I. PROTOZOA.

For our purposes we shall find it convenient to divide the Protozoa into three great groups, one of which has become degraded by parasitism; these are the **Sporozoa,** of which the best known division are the **Gregarinida;** the others, one of which is distinctly higher than the other group, may be called the **Sarcodina** and the **Infusoria.**

Of the **Sarcodina,** the best type is the common **Amœba,** which we have already studied; like it, all the members of the group move about and take in their food by means of those movements of the protoplasm of the cell which result in the formation of pseudopodia, and they reproduce themselves either by division or by budding.

In the **Infusoria** the amœbiform character is lost, and the cell has and retains a definite form; the ectosarc ordinarily sheds out a structureless membrane. This encloses the softer protoplasm which makes up the rest of the organism, giving off delicate processes which make their way through the limiting membrane; these processes, or **cilia,** are typically developed, are portions of protoplasm which retain their contractile power, and form the chief means of progression. Owing to the presence of the covering membrane or cuticle, it is necessary that there should be at some point an opening in the cell (**cytostome**), by means of which food may, at any rate, enter; this opening is ordinarily spoken of as the mouth; in addition to it there is sometimes a second orifice developed, which has the function of an anus (**cytoproct**).

The third division of the Protozoa are the degraded parasitic forms, of which the **Gregarine** is an excellent example. Though these cells are covered in by a distinct membrane, there is no orifice or mouth by which the food can enter; living as they do in the digestive tract or other cavities of the bodies of higher animals in which nutritious matter is abundant, they obtain such food as they require by the mere

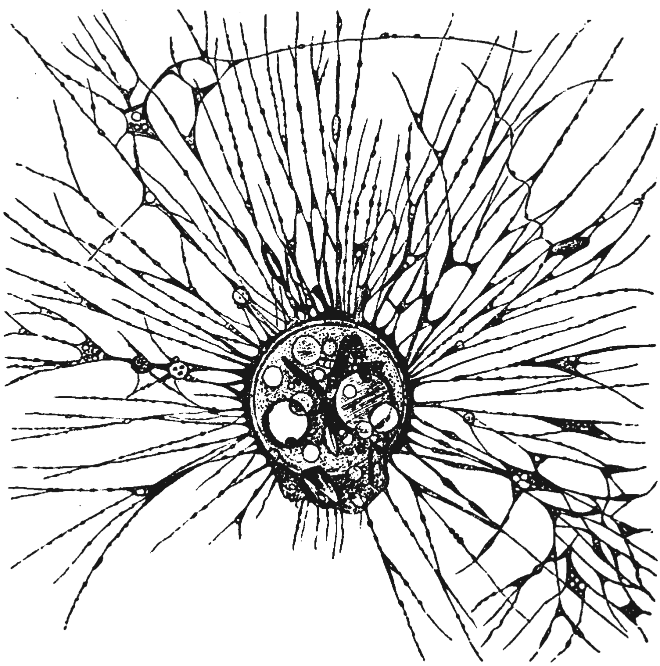

Fig. 2 A.—*Gromia*, showing the test and the protruding protoplasm.

physical process of osmosis. Similarly, having ceased to lead a free life, and abiding now in closed spaces, they have lost the cilia which were possessed by the infusorian and exhibit instead a slow serpentine movement which is effected by the ectosarc.

The Sarcodina are conveniently divided into three great divisions:

I. **Rhizopoda;** example: Amœba, Gromia, Nummulites.

II. **Heliozoa;** example: Actinophrys (Sun animalcule).

III. **Radiolaria;** example Acanthometra, Chilomma.

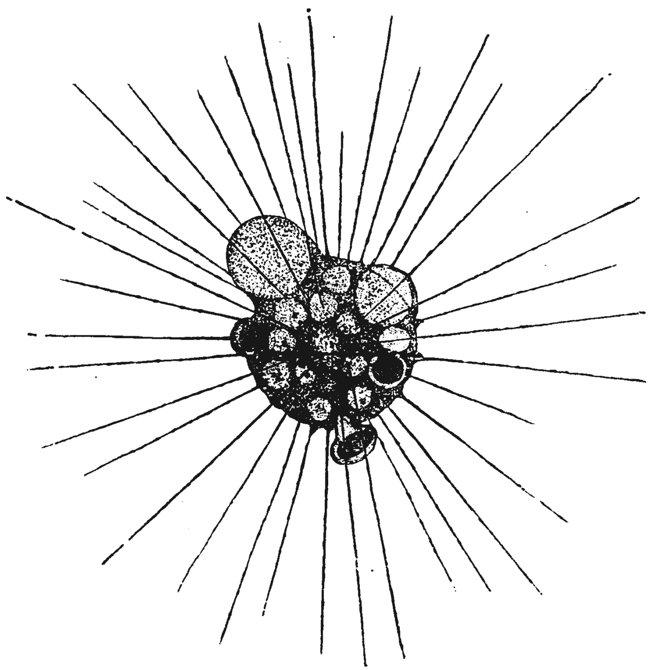

Fig. 2 B.—*Actinophrys sol*, showing the vacuolated ectosarc, the finely granulated endosarc, the nucleus, contractile vacuole, and pseudopodial filaments. (After Leidy.)

Leaving out of our consideration those simple and incompletely known forms in which no nucleus is developed in the protoplasm (**Monera**),* we may distinguish the naked Amœba-like Rhizopoda from those

* It is possible that in such forms the nuclear substance is diffused through the protoplasm (Gruber).

in which a covering or test is developed; this test may be chitinous (Gromia), or chitinous and calcareous, or, in rare cases, siliceous; and it may have either

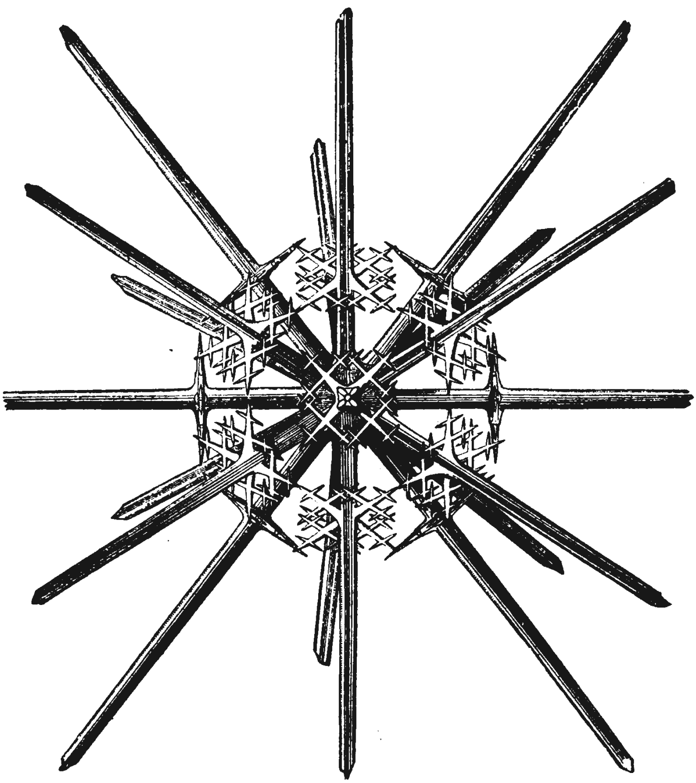

Fig. 2 c.—Xiphacantha, showing the siliceous skeleton. (After W. Thomson.)

a single large orifice (Fig. 2 A), or the test may be perforated with a number of holes (**Foraminifera**), and may attain to a large size (Nummulites), and great complexity of form.

The **Heliozoa** either have the body naked or a siliceous skeleton is developed; the body is very commonly spherical in shape, while the pseudopodia (Fig. 2 B) are fine, alter but little in form, and rarely anastomose with one another; lastly, the **Radiolaria** (Fig. 2 C) have a chitinous "central capsule," around which flows the protoplasm, and with which there is

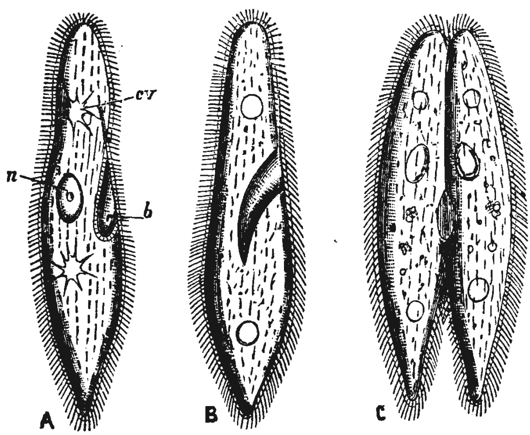

Fig. 3 I.—*Paramæcium aurelia*; **A, from the side; B, from below; C, two in conjugation.**

n, Nucleus; *b*, mouth; *cv*, contractile vacuole.

ordinarily connected a delicate and often elaborate siliceous skeleton. The pseudopodia are less constant in form than in the Heliozoa, and enter into anastomoses with their neighbours.

The **Infusoria** are ordinarily ciliated, but in some (**Flagellata**) the cilia are replaced by a single long whip-like process of protoplasm (**flagellum**) (Fig. 3 II.), and in others which are parasitic on (**ectoparasitic**) the bodies of other infusorians, the cilia are lost and replaced by tentacle-like sucking tubes (Fig. 3 III.).

I. **Ciliata,** as Paramœcium, Vorticella, and others; the cilia are either regularly distributed over the cell, and are, for the most part, subequal in **size** (Paramœcium) (Fig. 3 I.); or some are much larger than the rest (Stentor); or the cilia are ordinarily confined to a spiral circlet around the mouth (Vorticella), and are only occasionally found on other parts of the

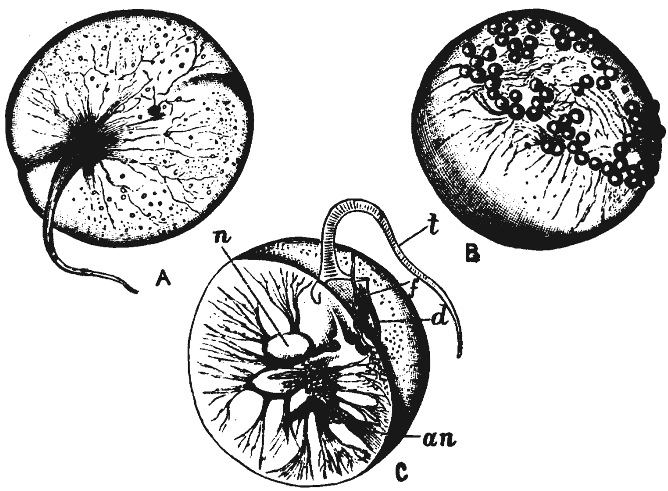

Fig. 3 II.—A, *Noctiluca miliaris*; B, with buds; C, section. *n*, Nucleus; *f*, flagellum; *t*, tentacle; *d*, denticle; *an*, anus.

body; or, finally, they may be limited to the so-called ventral surface (Euplotes); in the Peritricha, as the group to which Vorticella and its allies belong is called, there is often an elongated aboral stalk, which sometimes exhibits a remarkable power of rapid contraction.

II. **Flagellata**; a number of forms are grouped by some writers under this head; of such as are almost indubitably animal, Noctiluca (Fig. 3 II.), the animalcule which causes much of the diffused phosphorescence of the sea, is one of the best known.

III. **Suctoria:** in these parasites (*e.g.* Acineta, Fig. 3 III.), the mouth is lost and the sucking tubes protruded from the protoplasmic mass serve to convey food into the body. A study of their development reveals the interesting fact that they commence life as ciliated embryos, and suggests the idea that they are descended from ciliate infusoria.

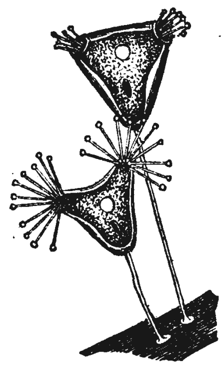

Fig. 3 III. — *Acineta tuberosa.*

The **Sporozoa** will, for the purposes of this book, be represented by the Gregarinida. The forms best adapted for study are the gigantic Gregarine found in the intestine of the lobster, and remarkable for being, though but a single cell, as much as two-thirds of an inch in length; and the much smaller species found in the testicular reservoirs of the earthworm.

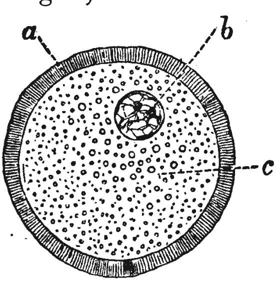

Fig. 4.—Ripe Ovum of Cat. (After Klein.) *a*, Envelope; *b*, nucleus; *c*, protoplasm.

II.—THE METAZOA.

STRUCTURE AND EARLY HISTORY OF THE EGG-CELL.

The key to the structure of the higher animals, or **Metazoa,** is to be found in a knowledge of the early history of the egg from which, as has been already said, they all arise. This cell, when mature, consists of a mass of protoplasm (Fig. 4, *c*), with a central nucleus (*b*), and contained nucleolus, and in most, though not in all cases (Hydra), it has a definite investing membrane (*a*). Under normal circumstances this egg-cell is fertilised by the male element (chap. xiii.), and then commences to undergo a process of cleavage, or division. It first divides into two cells, which are, in the simplest cases, equal in size; each of these again divides, so that there

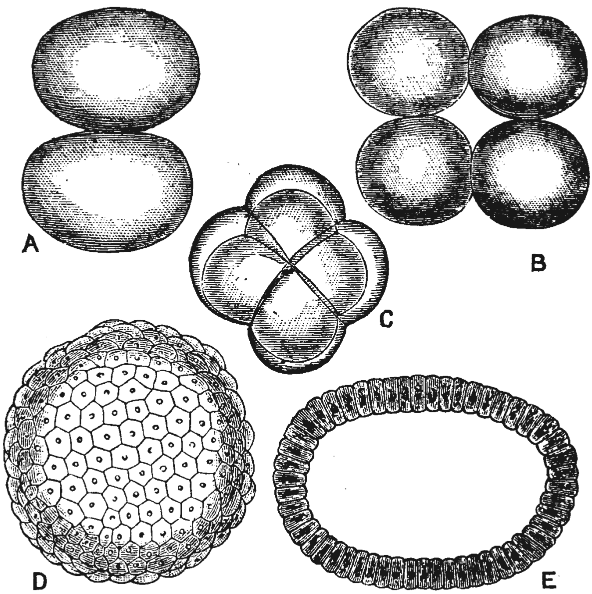

Fig. 5.—Segmentation of *Amphioxus*.

A, Stage with two equal segments; B, with four; C, with eight; D, segments enclosing a segmentation cavity; E, somewhat older stage in optical section. (After Kowalevsky.)

are four, then eight, and so on. After a time the process of **segmentation** (Fig. 5) comes to an end, and then we have a mass of segments, which are either closely applied to one another, and so have a kind of mulberry-like appearance (hence the name of **morula** applied to this stage); or, as is more common, the segments separate from one another during the process of division, and give rise within to a space, the **segmentation cavity;** the cells bounding this cavity then undergo a further change, by means of which the single becomes replaced by a double layer, one of which is interior to the other.

This two-layered condition is brought about in one of two ways; either the cells of one half of the sphere are pushed into the contained space, and, by approaching the other half, more or less completely obliterate the segmentation cavity, or the cells undergo a transverse and concentric cleavage, by means of which each cell becomes two, and the single is converted into a double layer. Whether the former process (that of **invagination**) or the latter (**delamination**) takes place, the cell-layers are regarded as comparable, and receive the same names; the outer is known as the **epiblast** (Fig. 6, *ep*), the inner as the **hypoblast** (*hyp*). Similarly the contained cavity, which is clearly the segmentation cavity in the latter mode, and an altogether new formation in the former, is spoken of as the **archenteron,** while the narrow opening to the exterior is the **blastopore** (*o*). The whole organism is now said to be in the **Gastrula** stage (Fig. 6).

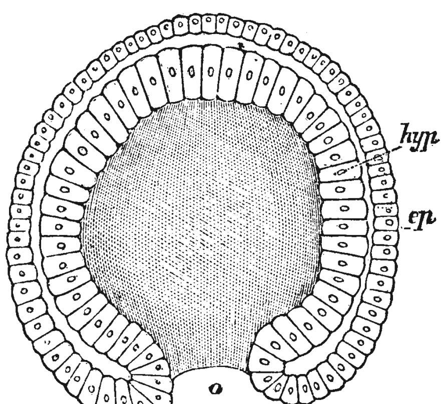

Fig. 6.—Diagram of a *Gastrula*.
o, Blastopore; *ep*, epiblast; *hyp*, hypoblast.

No known animal remains at quite the low and undifferentiated condition of a Gastrula; and, indeed, in most cases yet another **germinal layer,** as the epiblast or hypoblast is respectively called, is developed between the two we know already. It is appropriately spoken of as the **mesoblast;** it arises in various modes, into the distinctions of which we need not enter here; it will suffice for us to know, that in all the higher Metazoa the greater part of the organism is fashioned out of it.

In all cases the outer and inner layers undertake the functions which their position entails on them; the cells of the epiblast become converted into the parts which cover in and protect the rest of the body, and give rise also to those organs by means of which the organism becomes acquainted with what is going on around it, **sensory organs** and **nervous system.** The hypoblast remains always in connection with the **enteron,** or digestive tract, forming the lining of its walls, of the glands that are therein developed, and of such outgrowths as may arise from it. In the lower divisions of the Metazoa the mesoblast does not take any large share in the formation of the organs; it remains in a more or less indifferent condition. In the higher forms it becomes quite the most important layer in the body, taking on as it does the duty of developing the skeleton, the muscles, the blood, and vascular system, the excretory organs, and the connecting tissues; it always, also, becomes primarily cleft or divided, so that a cavity is developed within it; this is the true body cavity, or **cœlom,** and all animals that possess it may, whether they secondarily lose it or not, be spoken of as the **Cœlomata.**

The acœlomate Metazoa are the sponges (**Porifera**), and the great group to which belong hydra, the jelly-fishes, and the sea-anemones (**Cœlenterata**). The simplest sponges show hardly any advance on the typical Gastrula, the amount of mesoblastic tissue developed being small; but they are remarkable at once for a character which sharply distinguishes from all other animals. It happens to many Gastrulæ that, their blastopore closing up, they develop an investment of cilia on their epiblast, and swim about for a time freely in the water; but these cilia are confined to the outer surface. In the sponges it is otherwise, the ciliated cells early become internal to the non-ciliated, and some are retained throughout life in the so-called "ciliated chambers." When we come to examine into the activity of a living sponge we find no advance on that of a Protozoon, save so far as the division of labour is here first clearly seen; we find, that is, that the multicellular organism feeds, grows, respires, reproduces itself, and dies; and we find, too, that, like many Protozoa, it forms for itself firm supports in the way of a skeleton, but we find no cells that are specially sensory, and none that are obviously muscular; there is the general irritability and contractility which living protoplasm always exhibits, but there are no special organs for either function.

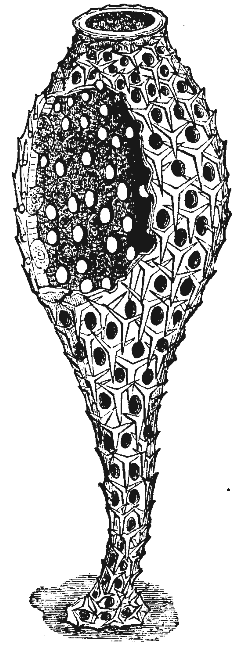

Fig. 7.—Calcareous Sponge. *Ascetta primordialis.* (After Haeckel, × 50 diams.)

The **Porifera,** or sponges, fall into the following divisions:

1. **Myxospongiæ,** in which there is no hard skeleton; *e.g.* Halisarca.

2. **Calcispongiæ,** in which a support for the body is furnished by calcareous spicules; *e.g.* Ascon,

Leucon, Sycon. The commonest British form is ordinarily known as Grantia. (*See* Fig. 7.)

3. **Silicispongiæ,** in which part of the skeleton is made up of spicules of silica; *e.g.* the common fresh-water sponge (Spongilla), Chalina, Euplectella.

4. **Ceratospongiæ,** in which the skeleton is

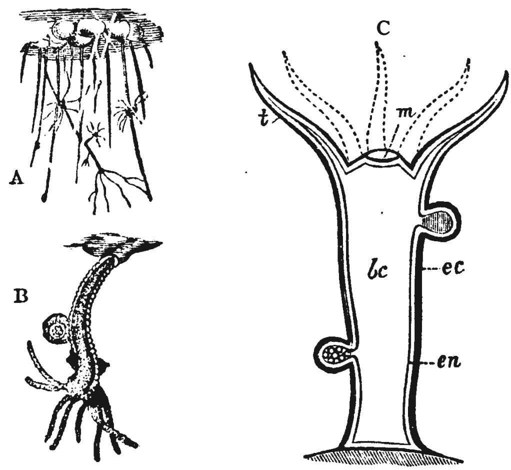

Fig. 8.—A, *Hydra v ridis*, attached to Duckweed; B, a Single Specimen magnified; C, *Hydra* in Diagramatic Section.
ec, Ectoderm; *en*, endoderm; *m*, mouth; *bc*, enteric cavity; *t*, tentacles.

completely horny or fibrous, and devoid of siliceous or calcareous spicules; *e.g.* the bath-sponges (Euspongia).

In the **Cœlenterata** it is otherwise; in many forms both nervous and muscular tissues are to be recognised not only by the aid of the microscope, but by the activity of these animals, and by their reactions when subjected to physiological experiment.

Henceforward, then, we have to do with forms which possess, in some shape or other, all the essential tissues of even the most complicated organisms; differentiation will lead to greater subdivision of labour, and greater complexity of structure, but all the materials are, even so low in the grade of animal life, ready to our hand.

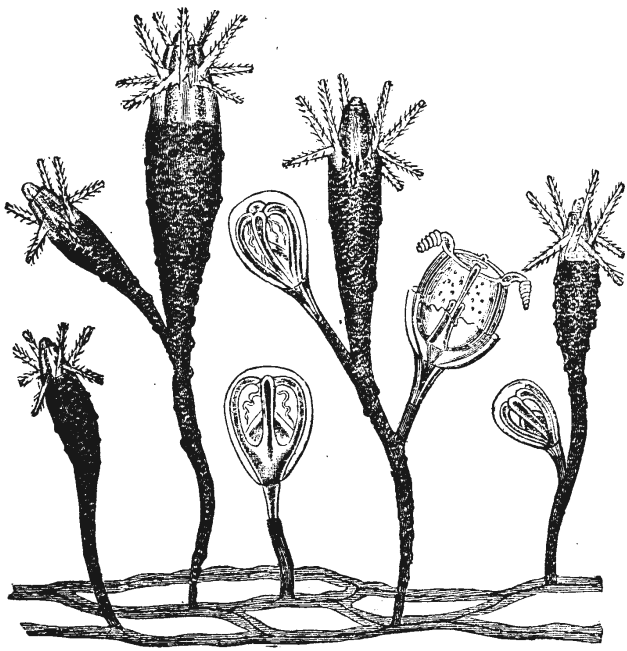

Fig. 9.—*Perigonimus vestitus,* showing Trophosomes and Gonosomes (After Allman.)

A cœlenterate animal, then, is one in which the archenteron of the gastrula, even when secondary outgrowths are developed from it, remains always as the only cavity in the body, in which the mesoblast is but imperfectly differentiated, but in which organs of offence, locomotion, and sensation are added on to the structures of the original gastrula form.

In its simplest known condition, *e.g.* Hydra (Fig. 8), a Cœlenterate has a terminal mouth (*m*) which leads into a digestive cavity (*bc*), and around which tentaeles (*t*) are developed; these tentacles, which serve as organs of prehension, sensation, and offence, are hollow, continuations of the enteric cavity passing into them. There is no second orifice to the enteron, and reproduction is effected either by gemmation, or by the formation of ova and spermatozoa.

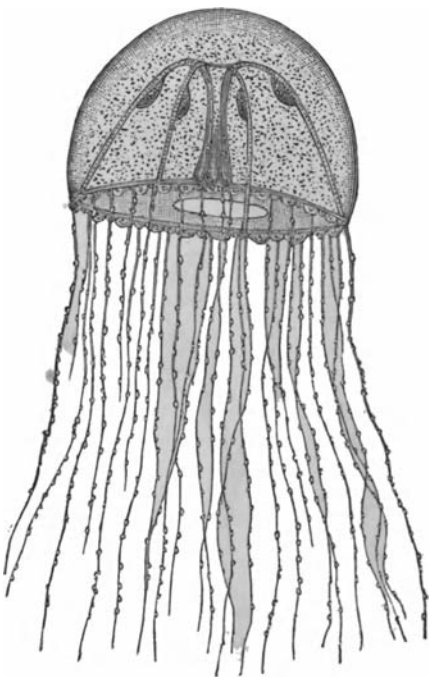

Fig. 10.—Figure of the *Medusa* of a Hydroid. (After Hincks.)

In the more complicated members of the group the hydriform body gives off buds, and becomes one of a **colony** (Fig. 9); and the separate "persons" of this colony are connected together by a common trunk, which is hollow within, and continuous with the enteric cavity of each person; in the simplest stage of these colonial formations each person performs the same duties, but in the more complex different persons take on different duties; when these, again, are at their simplest stage, we find that while some nourish the colony (**trophosomes**), they take no share in reproducing it; this office is performed by other persons (**gonosomes**), which depend for their nourishment on the neighbouring trophosomes. Division of labour among the persons of the colony may go still farther, and groups become formed of which some have nutrient, others locomotor, others protective, and others prehensile or offensive functions (Siphonophora; *e.g.* Portuguese man-of-war) (Fig. 12). Where the Cœlenterate is fixed, we observe, in one division, that the generative persons become free-swimming, and, while retaining the essential characters of the division, become greatly altered in form, in adaptation to their new mode of life; such persons are spoken of as **Medusæ** (Fig. 10). Finally, we find that, in some cases, the fertilised ovum of a medusa gives rise not to a fixed hydra-like body, but directly to a medusa form. The tentacles are set round the mouth in a circle, and the parts of the body are similarly arranged in a fashion of symmetry, which is called **radial**; where, however, the free mode of life has obtained for a long period of time, we sometimes find that there is only one axis of the body on either side of which exactly corresponding parts are to be found; in other words, a **bilateral**

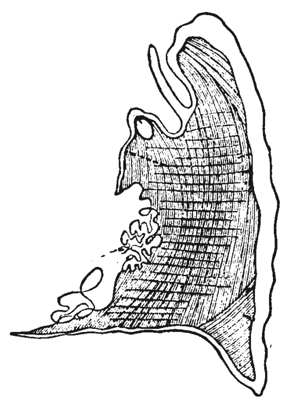

Fig. 11.—Longitudinal section through *Sagartia parasitica*, showing a mesenteric septum with the body wall to the right, and the enteric wall to the left. (After O. and R. Hertwig.) (*See* Fig. 54.)

takes the place of a radial symmetry; *e.g.* Venus' girdle among the Ctenophora. (*See* Fig. 16, page 46.)

The **Cœlenterata** fall into two well-marked divisions, **Hydrozoa** and **Anthozoa;** in the former the mouth is placed on a projecting oral cone, while in the latter it is sunk below the level of the oral circlet of tentacles, and the cavity developed from the enteron, and separating its wall from the body wall, is traversed by partitions (**mesenteric septa**) (Fig. 11), of which a certain number extend across the whole of the cavity, while others only project for a shorter or longer distance into it.

CŒLENTERATA.

A. **Hydrozoa.**—The hydrozoa fall into two well-marked divisions, in the first of which the medusa form, when developed, always has an infolded rim of the body running round the inner edge of the mouth of the bell (**velum**). In consequence of the presence of this fringe it may be spoken of as the **Craspedote** division; in it the sense organs are never protected by any lid or cover, and they are therefore known as the Naked-eyed Medusæ (**Gymnophthalmata**), and as the generative sacs never form projecting pouches, they are by some spoken of as **Cryptocarpa.**

I. **Craspedota.**—The Craspedota fall into three groups; in the first the organism is always hydriform, or the nutrient persons are hydriform, and the generative medusiform, or the organism is always medusiform. They may, therefore, be called **Hydromedusæ.** Examples of these are: Hydra, Cordylophora, Hydractinia, Sarsia, Oceania.

In the second group we have those colonies of hydriform persons in which the common stem becomes richly impregnated with calcareous salts, and they therefore may be known as Hydroid Corals or **Hydrocorallinæ.** Such are Millepora and Stylaster.

In the third group we have those free-swimming colonies to which reference has already been made as examples of the highest form of division of labour: they are called the **Siphonophora,** and Velella, Diphyes, Physalia, and Physophora (Fig. 12) belong to this group.

Scyphomedusæ.—In the second great division of the hydrozoa we have the forms which are best known as the Medusæ, or jelly-fishes *par excellence.* With one exception, they all pass through a stage which, at first somewhat hydriform in appearance (**Scyphistoma**-stage), is remarkable for undergoing transverse division; each of the segments so formed separates and forms an independent medusa. When adult they are always medusiform in appearance, and, as they rarely have a velum to their disc, they are

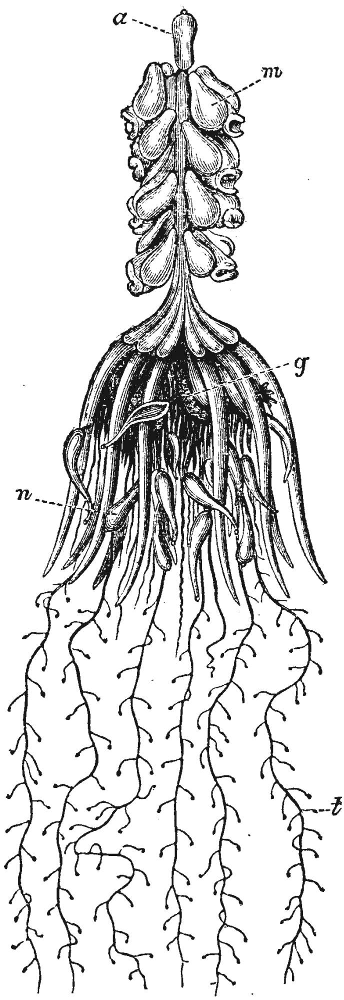

Fig. 12.—*Physophora hydrostatica.*

a, Air-bladder; *m*, nectocalyx; *g*, generative persons; *n*, nutrient persons (in the form of sucking tubes); *t*, tentacular persons. (After Cuvier.)

often spoken of as the Acraspedota; the term Steganophthalmata refers to the fact that their sense-organs are placed in protected recesses on the margin

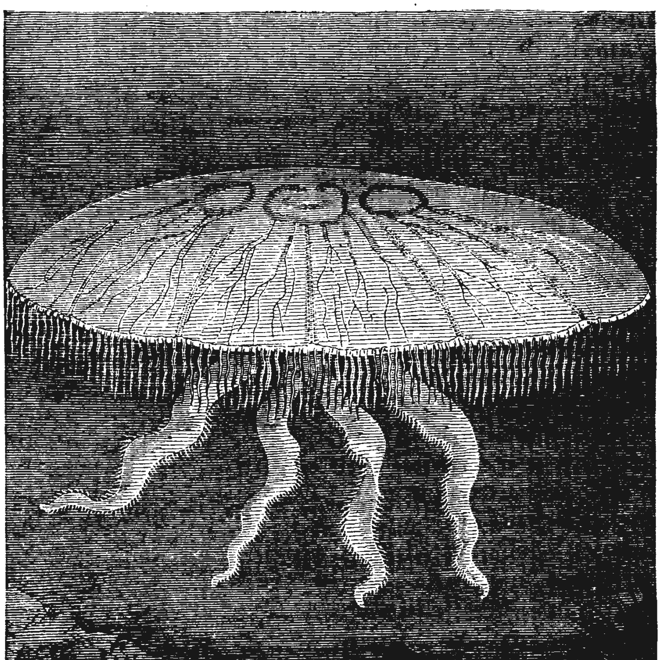

Fig. 13.—*Aurelia aurita.*

of the disc (covered-eyed medusæ), and that of Phanerocarpa must be altered from its original significance to mean only that the generative glands are large and obvious. They are ordinarily free, but Lucernaria is fixed; the common Aurelia (Fig. 13) is a typical example of the group, while Rhizostoma is an example of the forms in which the original mouth is lost, and replaced by a number of small apertures developed on the long arm-like outgrowths of its lips.

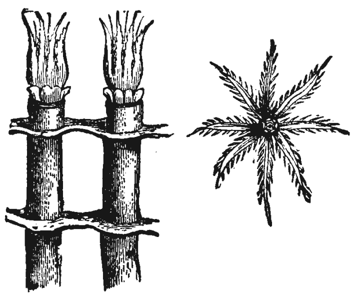
Fig. 14 A.—*Tubipora musica.*

B. **Anthozoa.**—Among the Anthozoa we find the sea-anemones and the great bulk ot those cœlenterates which form coral.

According as they possess eight, and eight only, or six, or some multiple (often a large one) of six, we divide the Anthozoa into the **Octactiniæ**, and the **Hexactiniæ.**

I. The **Octactiniæ** have never more than eight tentacles, and these are flattened and serrated at their edges. In Alcyonium ("dead men's fingers") cal-earcons spicules are scattered in the body; in Tubipora (" organ-pipe coral ") the spicules collect and form a continuous tube for each polyp (Fig. 14 A);

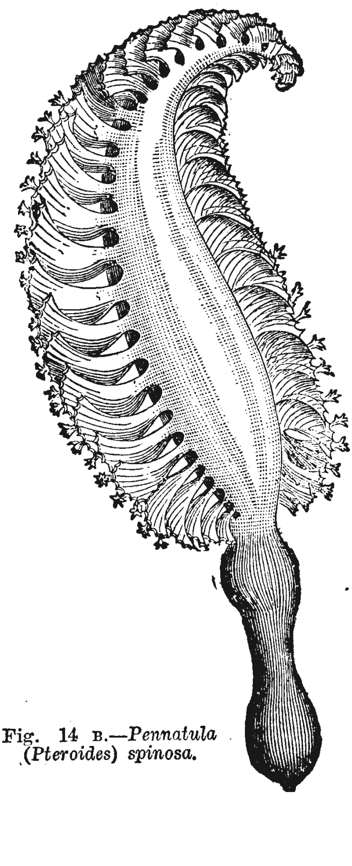
Fig. 14 B.—*Pennatula (Pteroides) spinosa.*

in the sea-pen (Pennatula) (Fig. 14 B), the tissue which connects the polyps together is horny, in the noble red

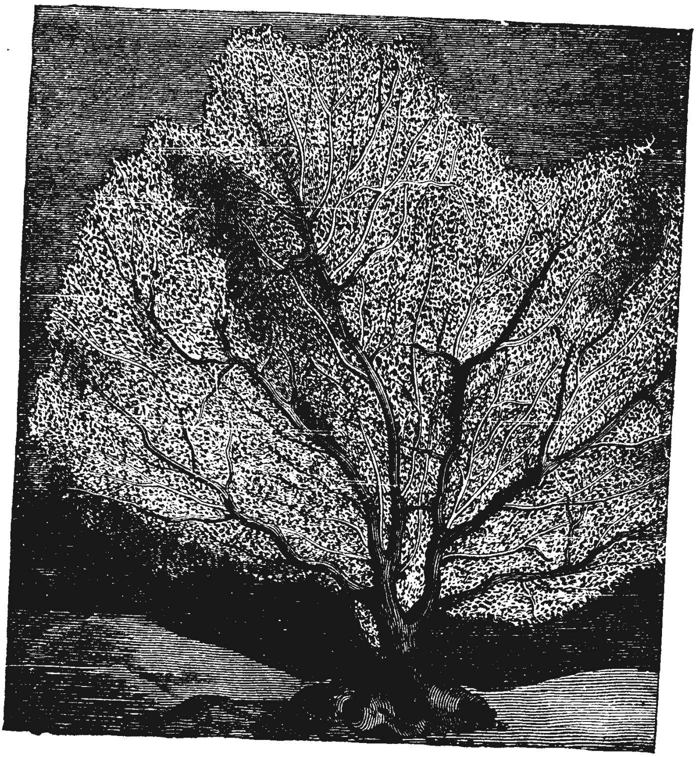

Fig. 14 C.—*Gorgonia flabellum.*

coral it is calcified, while in the sea-fans (Gorgonia) an elegant hard network is developed (Fig. 14 C).

II. The **Hexactiniæ**; the six tentacles or multiples of that number are filiform, and their edges smooth. Some, like the common sea-anemone, remain single throughout life, but, in most, buds are given off, and a colony is formed. The deposition of calcareous salts often gives rise to large masses of "stony" coral, of which the brain-coral (Mæandrina) is a good example; in other cases (*e.g.* Fungia) the septa are alone calcified.

There still remains a division of the Cœlenterata which, though it has been definitely placed by some naturalists with the Hydrozoa, and by others with the Anthozoa, is possibly an independent group; in these, the eight canals derived from the enteron run at equal distances close to the surface of the body, and along these there are formed bands of cilia, which have, in consequence of their comb-like appearance, gained for these forms the name **Ctenophora.** The glassy globe called Cydippe (Fig. 15) is found on our own shores, while Venus' girdle (Cestus veneris) is an example of that acquired bilateral symmetry to which we have already referred (Fig. 16).

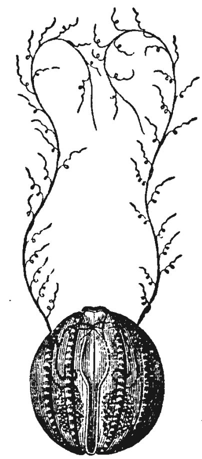

Fig. 15.—*Cydippe pileus.*

THE HIGHER METAZOA.

In the remaining Metazoa a cavity distinct from the archenteric cavity becomes developed, and the mesoblast becomes the seat of those important changes, by means of which nearly all the tissues of the body are derived from it. In the midst of this mesoblast a cavity arises by cleavage or fissure, or from the archenteron there are given off out-growths which, in time, become shut off from the parent space, and occupy the middle of the mesoblast. The cavity formed in either of these ways is spoken of as the body cavity or **cœlom,** and the result of its appearance is