THE AUTHOR

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Zoology for Everybody

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Eugen Kolisko

ZOOLOGY FOR EVERYBODY

A Series of Lectures

BY

EUGEN KOLISKO

(M.D. Vienna)

1st LECTURE

Illustrated

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EDITORIAL.

THIS series of lectures which we are now beginning to print, was given by Dr. Kolisko in 1932. Here is a successful attempt to achieve a real understanding of the animal kingdom, using as a master-key knowledge of the three-fold human organism. We refer to our previous publications dealing with this subject. It is of the utmost importance to-day to gain a real understanding of Man and the whole Universe, Man's connection with the animal world and plants and minerals. We shall never reach a real *social* understanding, if we do not understand from a spiritual standpoint man's central position on earth and his responsibilities towards his fellow beings and nature around him.

The present publication has been made possible by generous donations, for which I am deeply grateful.

The numerous sketches which help towards a better understanding of the complicated subject are due to Miss Gladys Knapp. The lectures had been accompanied by a wealth of lantern slides and cannot be published without numerous illustrations. We hope that they will prove useful for teachers and pupils alike. There are many books on zoology and animal biology, but we strongly object to the way this subject is presented to the public. If we open such a book we constantly read about: the machinery of the animal body; the machinery of co-ordination; the machinery of inheritance, and so on. Or we find an explanation of "living-matter" and "non-living matter" by comparing on the one side a piece of chalk or a motor bicycle as representing the non-living entities, and on the other side "a frog or a university professor"* represening the living matter. If we teach, for instance, zoology so that we constantly compare a human being with a frog, we shall never make the pupil understand the central position of man. We live in a machine-age, so the universal trend is to compare everything with a machine. The human body, or the animal body, or the plants, everything which is so miraculousa in its structure and relationship is explained by terms borrowed from the field of mechanics. Thus we lose the attitude of reverence and awe which alone are worthy of a human being in his approach to science and life. If we look upon man as perhaps a very complicated machine, but still as a machine, then we also do not mind so much to destroy this living entity; of course it is different when we start to think about a soul or human spirit; about the human body as a temple in which God may dwell. Science can be constructive or destructive. Let us build on a constructive science, let us strive for knowledge which leads to wisdom, let us strive for a science which has not only brains, but also a heart.

L. Kolisko.

November, 29th, 1944.

*See Lancelot Hogben, *Principles of Animal Biology*, 1942. George Allen & Unwin, Ltd.

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ZOOLOGY

I.

The key to the understanding of the animal kingdom is man.

Whenever we try to understand the infinite variety of animal forms, we find that they always remain a riddle, unless we consider them in comparison with the human being. How can this be done? This series of lectures aims at studying zoology by establishing the connections between man and the animal world. The touchstone for understanding the animal kingdom is the knowledge of the one-sided-ness of the structure of animal's bodies compared with the universality of man. The human body is distinguished from all the animal forms through the peculiar fact, that its various parts are distributed in a one-sided way throughout the whole animal kingdom. Each animal may be compared with one part of the human being. Man comprises in himself the whole, in a perfectly harmonized way.

With this idea we will try to understand the animal kingdom. We begin by giving a general introduction to this complicated subject. The details will be fully explained as we proceed to the various species, and study their modes of life and the characteristic qualities of single animal types.

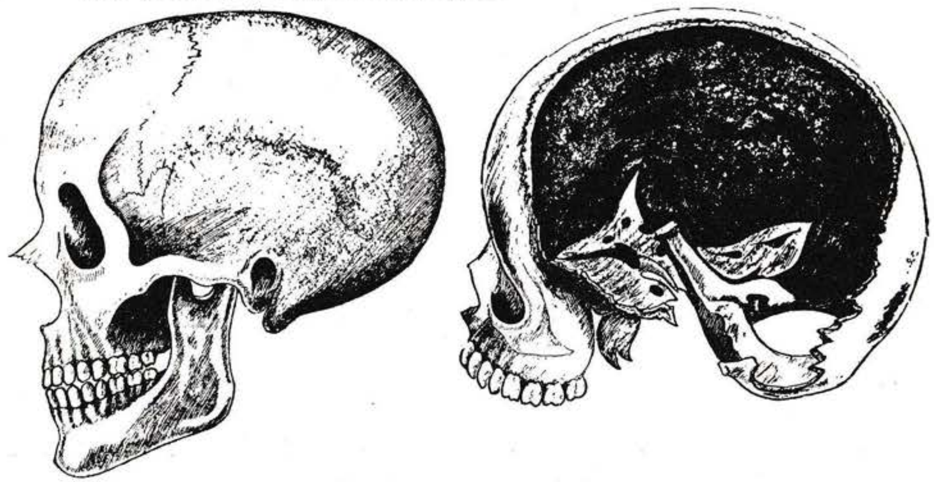


Fig. 1.—(a) Human Skull.
(b) Human Skull opened to show the space provided for the brain.

Let us look first at that part of the animal kingdom which stands near to man, at the animals which show a certain similarity to our bodily structure, with which we are intimately acquainted, the *mammals*. This group comprises animals living on the land as well as the more highly developed water animals, the whales. We may compare the human skull with those of various animals. Let us take an example: the skull of a ruminant.

Fig. 2.—Skull of a Ruminant.

This skull is remarkably massive, especially in the lower parts. The space provided for the brain, in comparison with the whole skull, is very small. The space allotted to the human brain* is very big in comparison with that of the cow (Fig. 2), where the

*See also comparative sketches on Plate I.

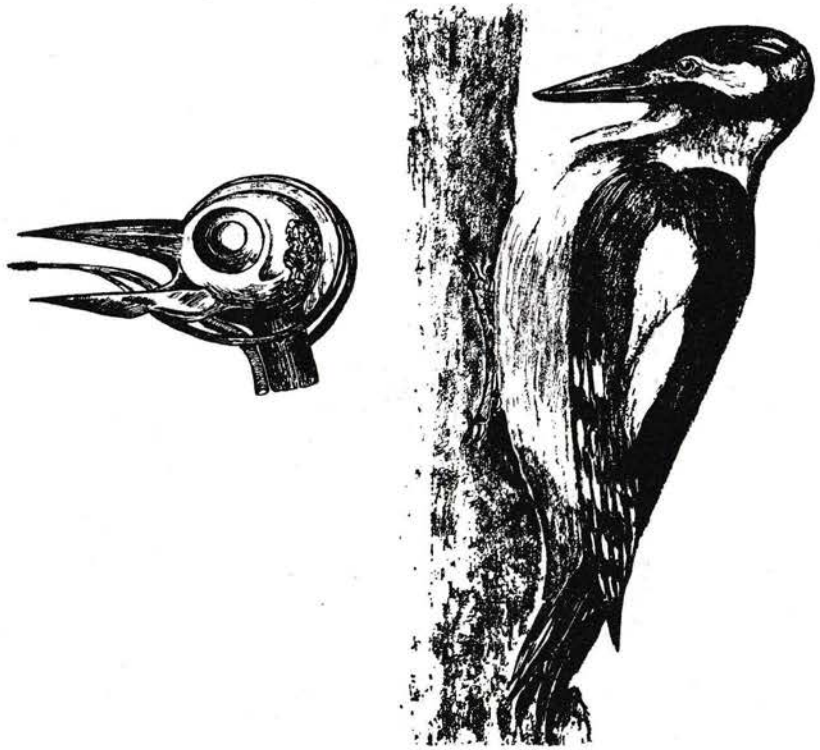
greatest volume is allocated to the teeth, the jaws and the lower part of the head.

If we study the skull of a tiger, we see, that it has not much room left for the brain. Other parts are specially developed. It is the middle part which is especially evolved in predacious animals. The teeth are very strongly constructed.

If we study the teeth formation of a ruminant, we have the impression that there are not many teeth. The cow has gaps in the front and only the back-teeth are of importance.

The *predacious* animals develop especially the middle or *canine-teeth*; they dominate the whole of the teeth formation.

Again, if we take another animal, a *bird*, for instance a *woodpecker,* we notice, if we look at the skeleton, that the eye is enormously big, but both the lower and the middle part of the skull formation are practically negligible.

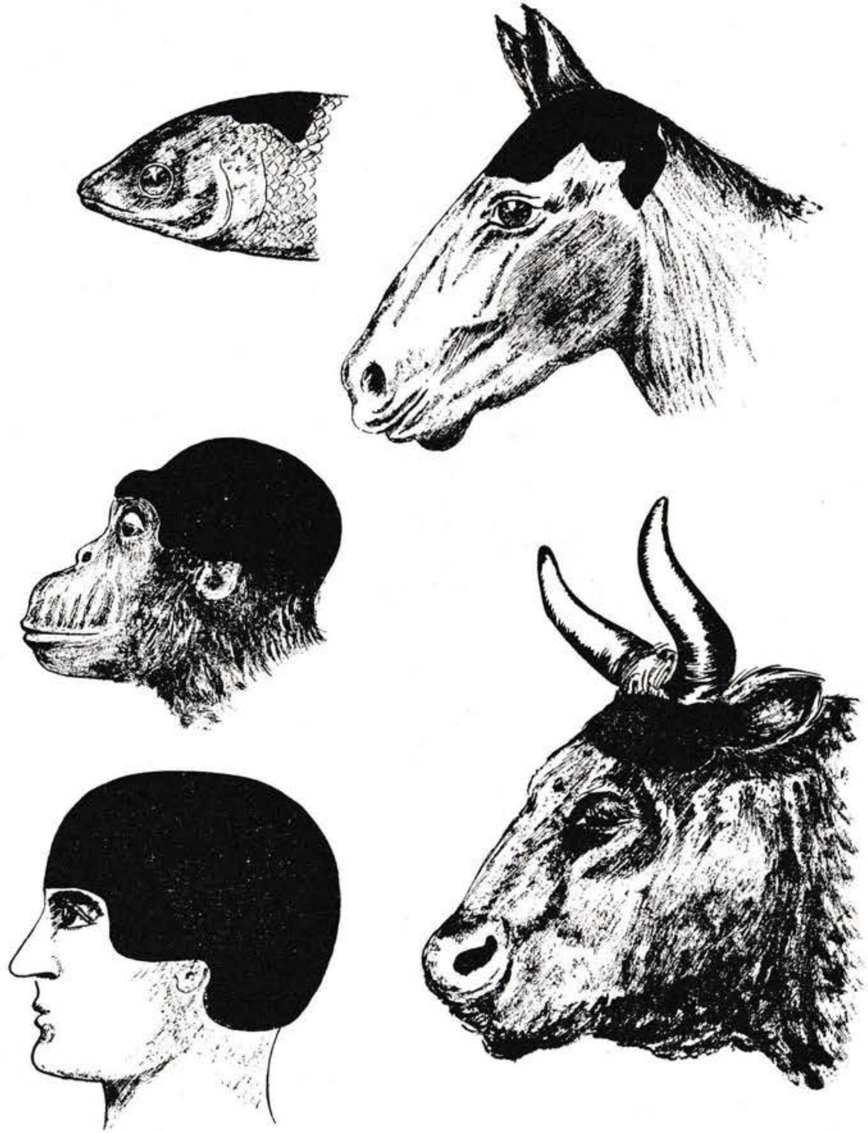


Or in the Toucan we see an enormous beak on a tiny head.

Fig. 4.—Toucan.

In the living bird it is not so obvious as in the skeleton, which gives the impression that here is hardly any lower part developed on the head.

PLATE I.



(according to Kahn).
Approximate proportion between face and brain of Fish, Horse, Ape, Man

Reverting to the human being, we may say that the human skull is built in perfect harmony. The upper, middle and lowe1 part are well proportioned to each other, they are developed in a balanced, harmonized way.* This is again obvious in the teeth. The ruminants have only developed the molars. They chew their food according to the structure of their back teeth. Predacious animals are built for the purpose of tearing their prey to bits, and develop foremost the canine teeth. They have a different way of chewing from the ruminants. In rodents the front teeth are especially developed. In birds we find no teeth at all. The develop ment has proceeded in a forward direction, no teeth can be formed. There is the horny substances of the beak, which cannot be compared with a tooth.

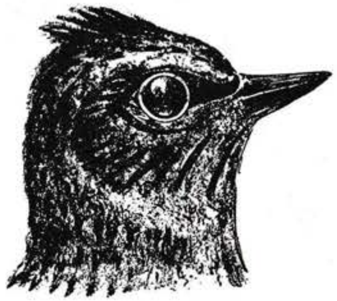


Fig. 5.—Skylark.

So we find *three main types of teeth formation* in the ruminants, the predacious animals and the rodents: *Molars, Canine teeth* and *Incisors* are emphasized. The teeth determine the whole physiognomy of the animals, also their habits of life and their exaggerated development in one direction. An animal which is heavily burdened in the lower and backward parts of its head like a cow, must conseqently develop a specific metabolic or digestive system; and this bodily structure must accordingly influence the whole life of a cow. *The animal becomes a slave to the exaggerated one-sided development of its organism.* It must live according to its bodily development. What else can a cow do than eat the whole day long, and transform so many pounds of grass into its own body? The structure of the body necessitates the habits of life.

Or if an animal like the lion or tiger is burdened with a specific type of teetl what else can it do, but arrange its mode of life so,

*See illustration on page 12.

that its inner activity coincides with the outer sructure of its body?

Fig. 6.—Lion.

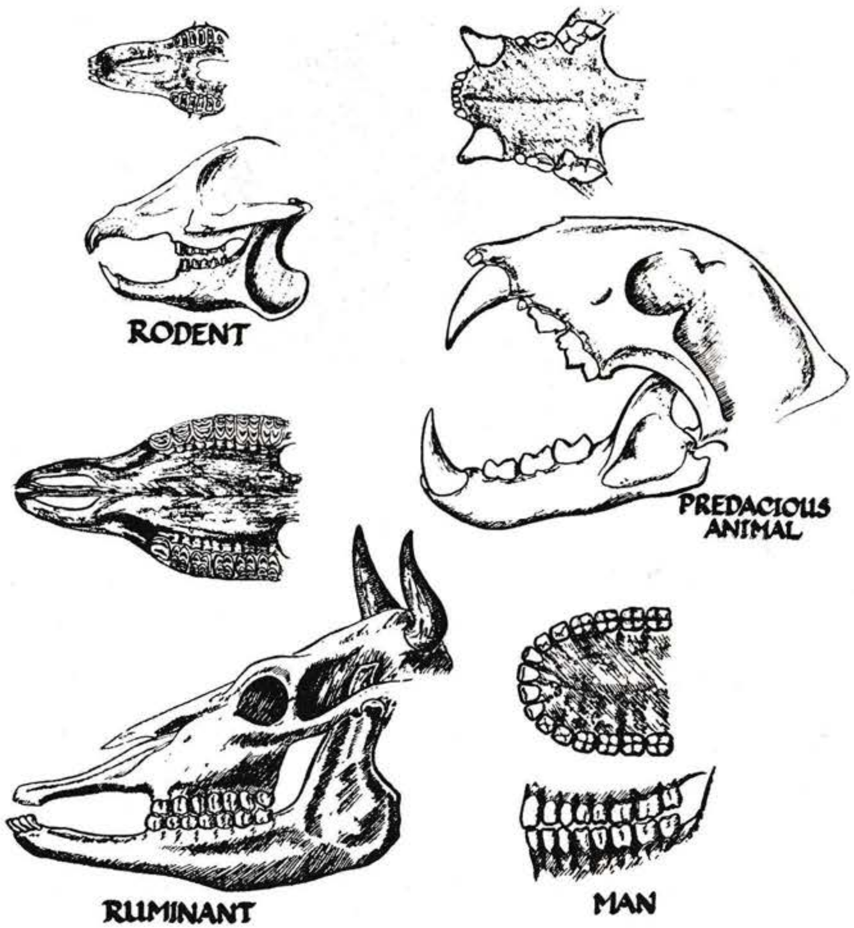
The special nature of a predacious animal is found in the predominant development of the middle part of its body, the thorax.

The nervous and destroying habits of rodents are due to their being burdened with gnawing front teeth.

We find that man does not develop any one of these three types of teeth predominantly. He develops the molar, canine and incisor teeth harmoniously. They are arranged in perfect harmony in a semi-circle.* That means, that man has various bodily functions accordingly. If a human being chews, he does this in all three directions at the same time. Gotthilf Heinrich Schubert, the great German philosopher of the 18th century, pointed out this phenomenon, that by comparing the human teeth formation with that of the various animal species, one sees quite clearly that the human being unites in himself these various groups, and even brings them to equilibrium. This can be seen also in the formation of the skull as a whole, but the teeth are very important since they determine to a great extent the physiognomy and mode of life. Of course we find the same phenomena expressed in the whole organism.

*See Plate II, page 12.

PLATE II.



Comparative sketches of the various types of teeth formations in Rodents, Predacious Animals, Ruminants and Man.

If we look at the structure of a bird as a whole, let us say a falcon or a rook, our first impression will be that the bird has

Fig. 7.—Rook.

not well developed legs; the metabolic system is likewise but weakly developed, but the lungs are enormously evolved, together with the whole breathing apparatus. The lungs extend themselves even into the bones, which are extremely light and are filled with air. We can say that the lungs penetrate the bones to the finest distribution of the air-channels in them, and this accounts for the fact that birds are so light. The lower part of the body is stunted, the bird does not need it; it does not really fit its organisation. A bird consists more or less of bones and skin and is, therefore, so light. It is permeated through and through with its breathing system, which makes flying possible. The senses are very alert, especially the eyes.* The capacity of far-reaching sight is much more perfect than in the human being. But again this is a one-sided accomplishment in the bird.

Comparing a ruminant with a bird, we see that in the former

*See Fig. 5, Skylark, on page 10.

much effort has been made to develop the metabolic system, the legs and the jaws. Less stress is laid upon the development of the brain, and upon quick and subtle receptivity of the senses. The sense organs are not very interested in the outside world. The cow has not such bright glittering eyes as a bird, for her gaze is turned towards the inside, and she has a dull, dreamy eye.

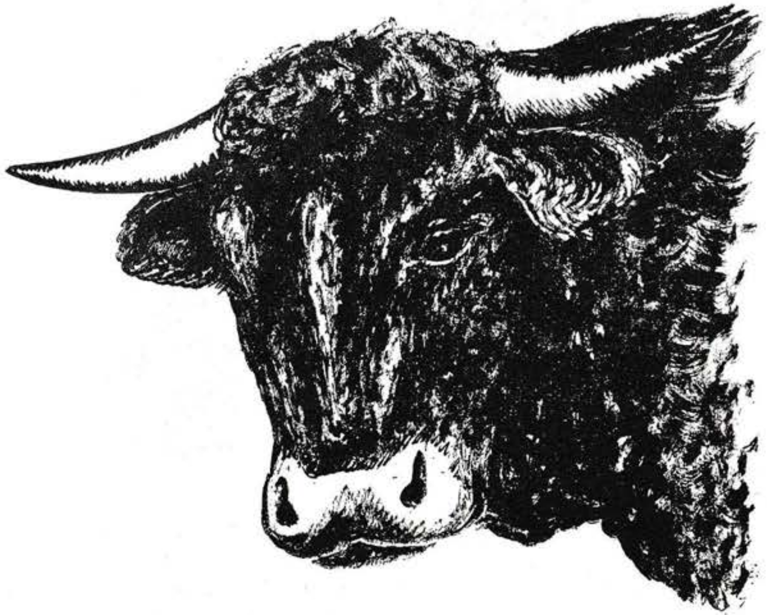


Fig. 8.—Cow.

We might say, that a ruminant directs its spiritual activity towards the development of the metabolic system, of the legs, and the enormous digestive tract, which must be kept constantly active.

The predacious animals show us an intermediate stage. For instance a lion or a tiger* does not use so much energy for its metabolic system as a ruminant; nor so much for the development of its lungs as the birds do. These feline animals keep the middle course. They cannot fly but they can jump. They have an enormous elasticity in their muscular system. Their food is

*See Fig. 6.

accordingly chosen especially to regenerate the blood and its specific activity.

I select these various examples that you may see the trend of these lectures on zoology. If I look at the skull of a human being and then turn my gaze to those animals which are nearer to man, then I find one type in the ruminants, another contrasting type in the birds; and in the predacious animals there is an intermediate type, which is in no way similar to man. If I look at the animals as a whole, not only at the skull, I find the same laws expressed. Looking at a single detail, for example the teeth, again I find the same phenomenon.

Man is placed in the animal world so that he has all the various parts which the animals have. He has not fewer bones than an ox, or a tiger. He has nearly the same bones, yet they are differently formed. He has also similar organs—liver, spleen, and heart—which are not very different from the animal organs. Yet there is an enormous difference between the animals and the human being, who keeps a certain middle position. This fundamental law is very important; it is a key for the understanding of man's relationship with the animal world.

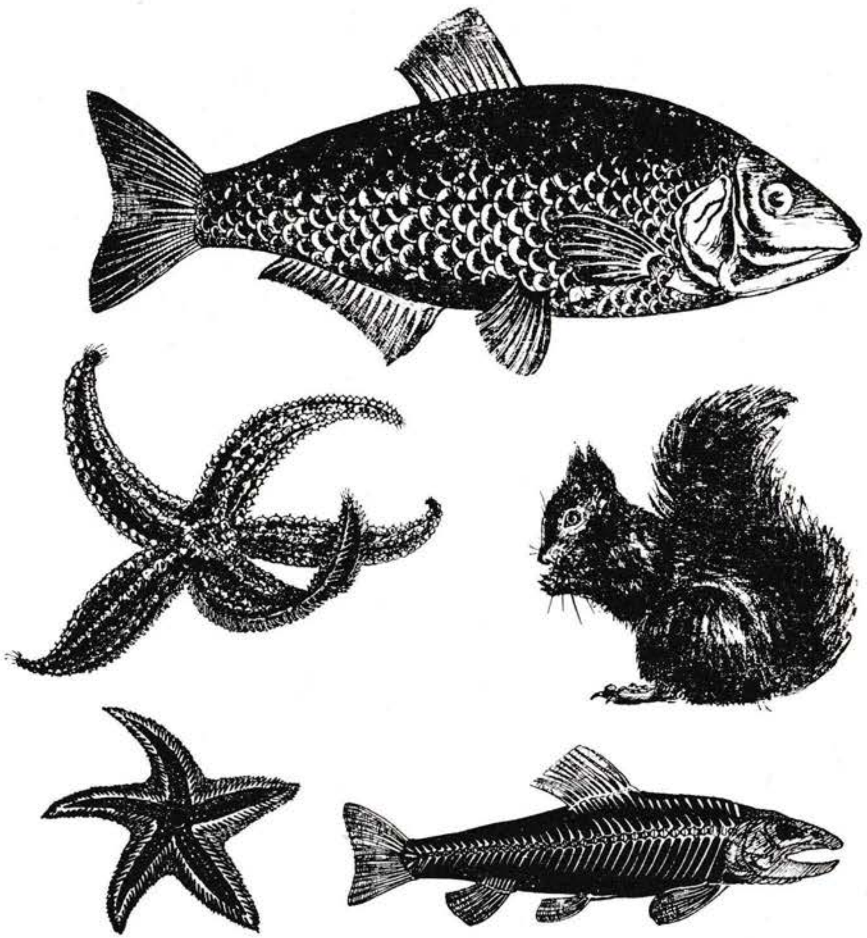
It might be thought that this is only valid for the more highly developed animals grouped round man. So we will consider other animal species, which will be dealt with in detail later on.

Let us select from the lower animal species the starfish, which is a soft animal; or we might choose an octopus. When we try to compare an animal of this type with the human being, the question immediately arises: how can these two be compared? Looking at one animal only, it is difficult to find an explanation, but if we take more species into consideration, derived from various animal groups, it becomes easier. Therefore we will take together, for example, the starfish, the fish (an animal which is not so strange to us) and a squirrel (Plate III).

If we compare these three types of animals we are struck by the following phenomenon: we look at the fish and find that it has developed specially that part which might be compared with the human *trunk*. It consists more or less of ribs, or rib-formations, numerous equally shaped fish-bones placed one beside the other. It has a spinal cord, bearing on the one side a relatively small head, and on the other ending in the tail. There are no real limbs, only fins, kind of elongated ribs. The structure of a fish must be described as consisting of a very small head, and a very long trunk. with no limbs attached to it.

In a mammal, such as a squirrel, or even in a lower species like a frog, we find limbs are developed.

PLATE III.



Fish, Starfish, Squirrel.

If we look at a starfish, we find that this animal is made very strangely. It has not only a number of flexible, strong arms (typically five), the peculiar thing is that at the end of each of these limbs is a sense organ, an eye. We are rather puzzled to say what these organs really are. Are they legs, or arms, or eyes? The limbs of a starfish cannot be compared with the limbs of any other animal. It is not such a very different process if a starfish looks, or walks about! It does both at the same time. Functions which have been separated in more highly developed animals or in men, such as seeing and walking, have been pushed into one another. In the centre of the starfish we find the mouth. This organ arises at the meeting of all the limbs, which form five teeth. On the one side the starfish walks and looks into the outside world, but it continues these functions into the inner parts of its body, so that it seems as if it were chewing at the same time. Various functions which are otherwise distributed all over the organism in more highly developed animals, have been contracted as it were in the starfish.

We find a similar phenomenon in the octopus, although we might even say, that there the development of a trunk-like formation starts. If we look at an animal like the octopus, which is one of the Cephalopody ("head-footed") Molluscs, it seems that

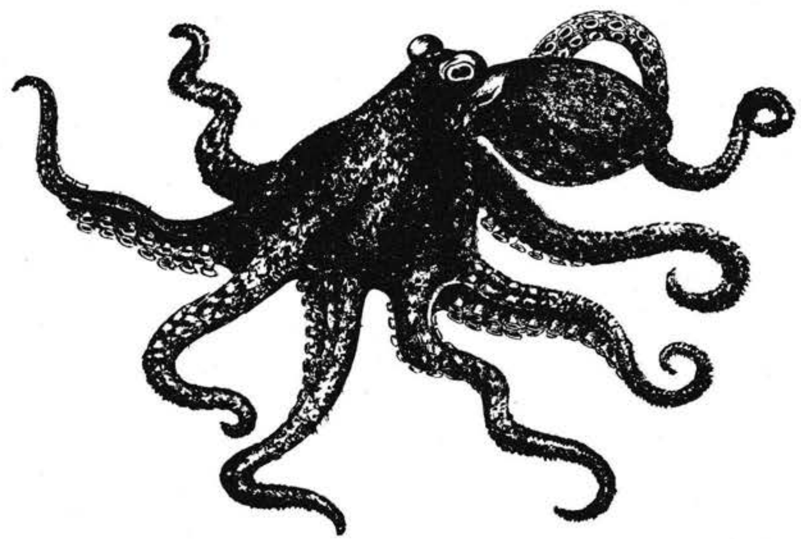


Fig. 9.—Octopus.

the feet are directly joined to the head. The whole of an octopus is not more than is found only in the head of man. We will come back to this later in describing more intimately the anatomy of the various animal species.

Slowly we come to the conviction, tha, if we study the lower species of animals like the jelly-fish, starfish, sea-urchin, octopus, that they show a structure which represents no more than the human head, but of course only in a soft form.

If we take a fish or some types of worms, they represent only the trunk, the middle part of the human organism.

As we come to the higher animal species, starting with the frog, and proceed to the mammals and birds, we find various types of limbs. With the development of limbs the whole organism is changed.

So we find in looking over the animal kingdom as a whole, again and again, that only parts of the human body are developed in the single animal species. This can be demonstrated to the most minute detail, but to-day I will limit myself to a few general examples.

When looking at an animal, we must always ask the question: which part of the human body is represented in this animal? If we find the answer to this question, it means the solution of the whole problem. If we can see which human organ is identical with the special animal before us, then we really understand it.

Which part, for instance, is the elephant?

It represents the upper lip, nose and front teeth of man, but, as it were, expanded in length. The rest of the elephant is not so important. The trunk and the tusks are the really interesting parts. In the trunk of the elephant there are as many nerve-fibres as in the whole of the rest of the body. It is amazingly sensitive. The trunk can lift a man from the ground on to the back of the animal, but it can also pick up a sixpenny coin. It can perform the most delicate and the most strenuous tasks. It is a most flexible and highly perfected organ. In none of his organs has man achieved such perfection. Also the teeth-formation of the elephant is remarkably developed. The tooth becomes a very precious substance, ivory, which can be used for many objects of art and may even serve as jewellery. The tooth (tusk) becomes so perfect, that it can no longer function as on ordinary tooth. It oversteps its perfection in an almost fantastic one-sided-ness. It is a well-known fact in the anthroposophical knowledge of man, that the development of the teeth is accompanied by various steps which represent mile-stones in the spiritual development of the child. From a material standpoint, the teeth are merely organs for chew-

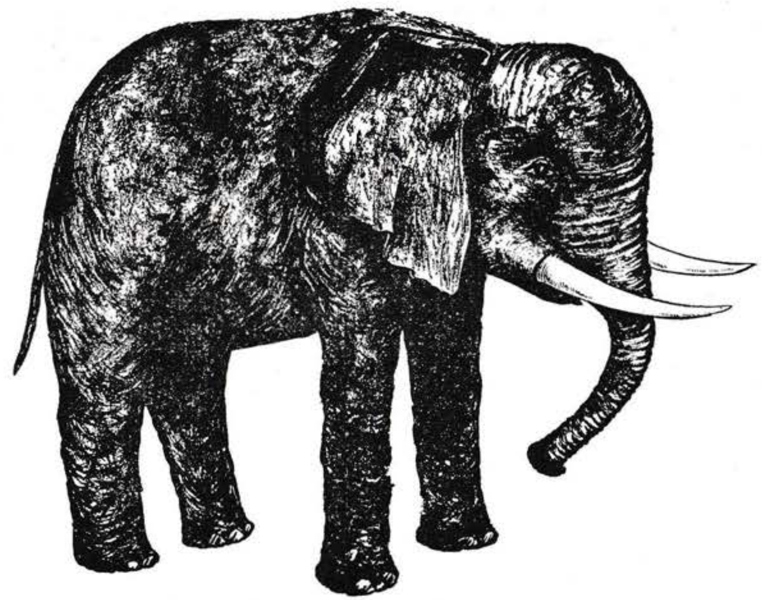


Fig. 10.—Elephant.

ing. But when the child has developed the first teeth, he or she also learns to speak; when the second teeth are formed, the child is fit to be sent to school. Still later it is a critical time in the development when the wisdom teeth appear. To cut a wisdom-tooth is almost equivalent to having an illness. The process of teething always causes a critical period, but at the same time a spiritual development takes place. It has the tendency to bring about a state of ill-health, and if this can be overcome, there is a gain in spiritual activity.

The elephant is known to be the wisest of all animals, and we may well connect this with the enormous, permanent formation of its teeth. We may even express this thought by saying that wisdom flows out through its powerful teeth. Combined with these fabulous tusks, it has an equally remarkable and sensitive trunk. The head, ears and legs appear grotesque and unfinished, as though formed by a novice in comparison with the perfect artistry of the trunk. So we must always ask in studying animals: which part is built with a certain perfection in comparison with the rest of the organism?

The birds are unique in that they form such an organ as the beak. The rest of the body is more or less neglected in the development. We may study here the "law of the budget." Goethe called these phenomena in nature "laws of the budget." The animal organism can only expend itself in one direction. When this has been done, the rest must, of necessity, remain imperfect. Man is not built according to this "law of the budget," he has achieved complete harmony.

The animals are one-sided, but in their one-sided-ness reach a higher perfection than the human being. This must be studied in every detail. Man is many-sided. He must learn. The animals need not learn. They know already because they have this perfect organisation. The human being has imperfect organs and must train them and later on he can rule over them, said Goethe. Man is universal and imprints into his life-organism what he makes out of himself. In this Man is different from the animal world. When we look at the various animals we must always ask: which part of the human organism has this animal developed? Studying this, we find the key for an understanding of the particular animal species. Man and animal explain each other. Studying the animal kingdom in this way we learn much about the human being. But there is also the possibility of man developing certain animal characteristics. If this were not so, the art of making caricatures would be impossible. If certain organs are extended or shortened in man, then a caricature appears—and it is always an animal caricature. This fact is well-known to the artists who excel in this art. It is easy to see in every human being a caricature which tends towards an animal. We always find it amusing if it happens that in Man, who really rules over the animal kingdom, there suddenly shines through some animal characteristic in its one-sidedness. Quite naturally man finds this contrast amusing. He is superior because he knows that in reality he excels the animal, but it is comical to see it peep through.

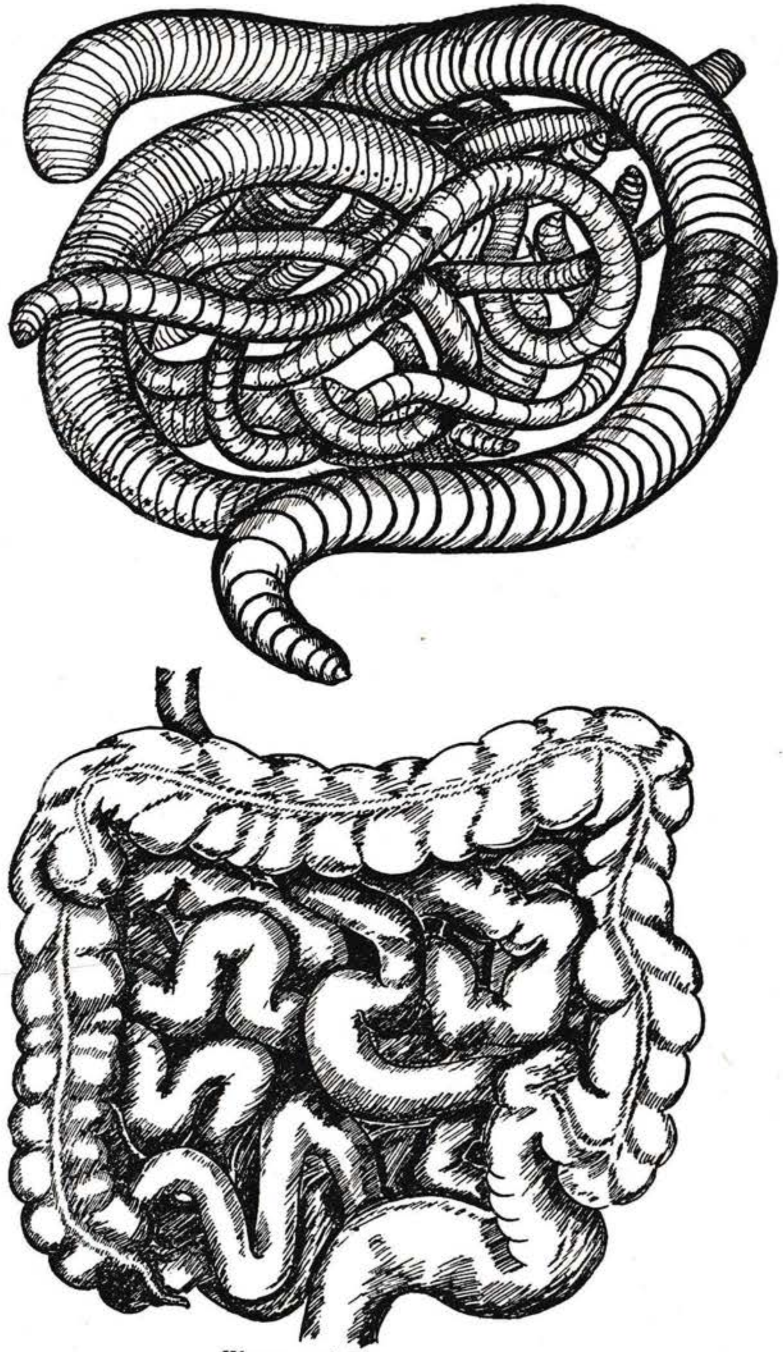
Now we may perhaps turn to a second problem. We may consider the animal kingdom as a whole; then that part which stands nearer to man, and the other part which stands more aloof. I want to make you aware of a cerain limit which is exceedingly important. This limit is at that point where for the first time animals become warm-blooded. These animals stand much nearer to Man than the cold-blooded animals, or those with changing temperature. There is an enormous gap between these two categories. The animals which are nearer man because thy have warm blood, include all the mammals and birds.

Mammals comprise all the ruminants, rodents and feline animals, all the big land animals which produce litters with living young ones they suckle, and the whales. Birds lay eggs, but they possess warm blood. The structure of these animals is very similar to that of the human being. They have nearly all the parts which a human being has; it is not that they are incomplete. In the birds one part is developed, in the mammals others are predominant, but the main structures are identical. If you study the skeletons you will find that in birds a few bones are missing, but they have almost the same bones, and also the inner organs are similar. We are astonished if some animals lack a part which the human being possesses; there must be a special reason if this happens. Modern Zoology shows that the structural plan is very similar in the animal kingdom and in man. This is true if we consider the number of organs and the various parts and the anatomical details. If we only look at these factors, then, most certainly, a great similarity exists. But if we consider the whole arrangement of the various details, then it is different. These animals furthermore have warm blood in common with man; that is they have a constant body temperature; they regulate their bodily warmth from within There may be some slight fluctations, but their temperature is more or less stable.

We find another characteristic in these animals. The main representatives, the birds and the mammals, have their bodies covered with a coat of feathers, fur or hair. We realise very strongly the enormous difference between the inside of an animal and the outside appearance given by the feathers, for instance, when we look into the inside of a corpse. In all the animals we find that the skin-cover is relatively independent of the animal itself. When we look at a hare, for instance, we have the impression that it is wearing a coat. The skin-covering can be moved about. The inner hare is separated from the covering skin. The same thing is apparent in the feathery coat of the birds. It covers the bird as a dress covers the body. Whales are similar, only they have a coat of fat; because they have warm blood something from the inside organism has to be taken as a cover. They produce something like an inner "coat" in the fat mantle. Every warm blooded animal which lives in the water must produce fat. The phenomenon that the inside of the body and the various organs are hidden, starts with the warm-blooded animals. The higher animals and man conceal themselves with the surrounding skin and fur or feather covering. These animals have warm blood similar to man, which makes them independent of outside influences. For example they can hatch eggs outside the body as the birds do, or instead of producing eggs with shells they keep their young ones warm from inside. The snake leaves it to the sun to hatch her eggs. The fishes show a still more extreme phenomenon, because there the fertilization takes place outside the body of the female fish, in the water. The hen does the hatching herself by sitting upon the eggs, and so does what otherwise might be accomplished by the sun.

After the kangaroo is born, it is immediately transferred to the pouch of the female, who carries the young one with her like this, until it is sufficiently developed. The pouch is concealed towards the inner part of the animals' body. A special organ is created which makes it possible for the young kangaroo to develop inside. What is outside in the lower animals withdraws more and more into the inside of the higher animals. With birds the hatching of the egg starts. Whereas the lower animals rely on outer nature forces, the sun, to hatch the eggs; this is now achieved by the body of the birds. The process of development becomes more and more an inner one. More and more the intensity of warmth-production rises. As far as reproduction is concerned, the capacity arises to create an embryo, a being growing within the body of the female animal. The higher animals become more independent of the outside world; they hide their inner structure with a fur or leather coat and the reproductive process is also withdrawn into the interior, so these animals become more similar to the human being. The differences between the various animal species are very great, the outside form is different, but the inner organs are relatively similar. The more highly developed animals are best understood by comparing them with the human being in the way I have tried to exemplify to-day. The higher animal world always points toward man. It is similar to man, and yet is a contrast to him, because of the development in a one-sided manner.

All those animals which are classified below the birds, that is snakes, crocodiles, frogs, lizards, worms, molluscs, starfishes, jelly fishes, all these represent the lower animal world. They have cold blood or at the most an unstable temperature. Here we find again a strange phenomenon. All these lower animals are connected with man fundamentally, still, if we look at a creature like a toad, or a frog, we have a strange impression that these are alien beings. The further down we look into the animal world, the more strongly we have this impression. For instance, take a worm. There we seem to be looking at a part of the intestines, at inner organs, or parts of the human anatomy walking about freely for themselves. (Plate IV).



Worms and Intestines.

All these animals are very different from those which have covered their bodies and are closer to man. In studying the lower animals we feel strongly that if we want to find something akin to these forms, we must look into the anatomy of man. The intestines of man are identical with worms and snakes in outer nature.

The great scientist Haeckel has written a beautiful essay about a jelly-fish which looks exactly like a free swimming human heart. It has the same physiology as the human heart, suspended in sea-water.

There exists a strong relationship between the sea-water in outer nature and all the various bodily fluids of living organisms, including the human blood. Let us for instance recall the fact that the phyiologists once had to invent an "Artificial blood" for the purpose of keeping the various frog limbs and rabbit-hearts alive as long as ever possible. Quite independently the zoologists were striving to find the formula for artificial sea-water to keep the sea animals alive. How great was the surprise of those scientists when at the end they discovered that they produced practically the same salt-solution substituting either sea-water or bodily fluids! In both liquids the four main salts are very similar in proportion:

Blood	Sea-water	
80	78	Sodium cloride ($NaCl$).
4	4	Potassium cloride (KCl).
4	2	Calcium cloride ($CaCl_2$).
2	15	Magnesium cloride ($MgCl_2$).

Since sea-water is similar to human blood it is comprehensible that so many "organs" are freely floating about in it. It is just as if you bring to the outside what is usually hidden inside. You have nothing but single organs and if you put some of these animals into bottles in spirit and place them besides other bottles containing various organs, such as a liver, a spleen, or kidneys, those two groups would look very similar. The higher animals are stuffed with material to preserve them. That is characteristic, that to keep the whole animal, the inside is filled out after the organs are removed. That is the opposite procedure to the one carried out in preserving lower animal species. The whole animal must be placed in spirit, just as you would do to preserve some inner organs of man or higher animals.

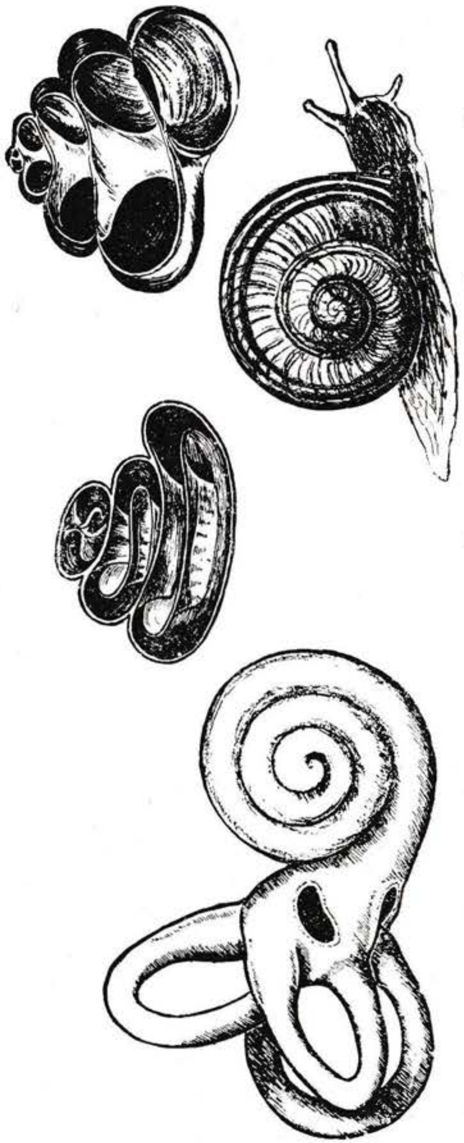
The higher animals have warm blood and must protect themselves outside with a skin, or fur, or feather-coat. The whole strength and formative force has to be directed towards the outside. This is imprinted in the outside animal skin. But we do not find this phenomenon when we arrive at man. The animal skin fits rather loosely to the body, and can be moved here and there. In man that character of a loosely fitting cover is completely lacking and the blood itself enters into the skin. In man the skin forms part of the inside and connects the inside with the outside. Only in man do we find the phenomenon that the blood shines through and gives the colour to his face. The lower animals are identical with the inner organs of man, but move about freely; that is why they sometimes look so unpleasant, for they give us the feeling that we are gazing into the interior of a human being. On the other hand there are some lower animals like the sea-anemones which have a tendency towards resembling the plant kingdom. They take on an appearance like plant blossoms and plant leaves; if the animal remains in the true animal realm, the lower species resemble anatomical parts; and later, with increasing development, it forms an outside cover, but this is not yet permeated with the inside forces. In man inside and outside penetrate each other and enter into a much closer contact.

The lower animal kingdom has cold blood. These animals are organs distributed in the outside world—freed inner organs. What is a polyp else but a free-swimming human guts? Sometimes we find mouth-intestine organisms, others represent other parts. You can tell definitely which organ they represent. Take for instance a snail. In the human body here is a similar formation in the ear, the cochlea. In the outside world an animal exists, which forms its body similarly to an organ hidden in man's body (see Plate V).

Thus always it is possible to show how inner organs enter freely into the outside world and build up the lower animal species; slowly these forms contract and are taken into the inside. The lower animal kingdom is extremely dependent on the surroundings. As we come lower down among the sea-dwellers, the animals start to form deposits. The lowest species have contributed to the formation of our planet earth. We would not have mountains if corals and shells and snails did not continuously deposit mineral substances. The lower animals enter the earth-building-process constantly, and participate in the forming of the earth. The lower the animals, the more they do so, and at the same time, they are immensely dependent on their surroundings. These animals have changing blood temperature; they are the free inner organs or the more highly developed animals and man.

And what does man do? He comprises in himself all the higher animals in the manner I have described. He collects all the various forms, but keeps them in balance. He does not allow some part to be formed exactly as it appears in a bird, or in a ruminant, he

PLATE V.



A.—Inner ear of man (cochlea and semi-circular canals).
B.—Section through cochlea of man.
C.—Snail.
D.—Section through snail shell.

equalizes the various tendencies. Into all these he fills the complete content of the lower animal world. This is an enormously interesting and important phenomenon, which may be studied in human embryology. There we can learn much in following up the various lower animal forms, together with the formation of the inner anatomy of man. In the later part of man's development in his life, when he starts to develop himself through his spiritual capacities, there we find that he is able to evolve as faculties what lives in the animal world in the form of instinct. It is not so easy, that, according to the theory of evolution we may begin with the lowest animal consisting of only a single cell, and then progress to more and more highly developed animals, passing through the various species until the apes, and finally end with man. You will find that the birds do not belong at all to man's antecedents, they only group themselves round him. The insects cannot be fitted in at all. They are so far away from man that we cannot find a connection with them. The relationship with the animal world is not so simple as we had at first imagined. In time we will learn to understand why it is, that not all these lines of evolution are passed through, when we study the various animal species and human embryonic evolution. Only a few groups appear in the human embryo. In the development of the inner organs we find many more analogies with the lower animal world than with the more highly developed species, and it certainly is very interesting to follow up these connections in detail.

There are great contrasts between the lower and the higher animals, between warm and cold blooded animals. The higher animal world is grouped round man; the lower one is related to his inner organs on the one hand; on the other hand it is intimately connected with the earth iself. The lower animals—we have mentioned this already—form deposits in the earth.

Just as man is surrounded by the higher animals, so the earth itself is closely connected with the lower animals. In man the higher animal world has been intimately interwoven; in the lower animals the inside of man has been exteriorized and it has become completely influenced by its surroundings. That means we are faced with a peculiar phenomenon in the higher and lower animal world.

We realise something else. If we take our present evolution theory, we find a great gap in that place in the animal system where we pass from the reptiles, or the old forms of reptiles belonging to the Jura formation, like the Saurians and dragons to the birds. It is a gigantic jump from the Saurians to the birds and mammals. If you study this from the geological point of view, you will find that there is an immense gap between the animal world which has its climax in the huge Saurians, and that other animal world which seems much more civilised, much more familiar, much more human. Something completely new appears in the so-called Tertiary-Formation. It is entirely different from the previous geological epoch. For the first time birds appear, and mammals, which can be compared with man, whereas the previous animals were much more remote from the human being. There is a great gap at this point in evolution. Therefore we must consider the higher animal world as having a different relationship to man, from that to which we have been accustomed. Our present theories of evolution, our ideas about the development of the planet earth take it more or less for granted that the whole animal kingdom, and finally man himself, have, as it were, developed from the earth. Primarily the earth was a huge nebular globe, then it became liquid and finally solidified. Then plants, animals and man evolved. We are accustomed to imagine an evolution starting from below, from the earth. We do not conceive the idea that once, at a certain moment in evolution, man must have entered the earth for the first time; that man is a spiritual being, who once incarnated himself. We have no place in our theory of evolution for the idea of incarnation. We imagine the whole development from below upwards. In reality we have to deal with a dual stream of development. The one stream is directed from below upwards, and is connected with the lower animal world, with the anatomy of man; and another stream, in the opposite direction, intermingling with the first one, is connected with the higher animal world, having warm blood and standing closer to man. These animals came into being in the moment when all the conditions on earth changed, where there is the great jump in the geological development from the Mesozoic Age to the Cainozoic Age; when all those gigantic animals, the Saurians, died out, and suddenly different animals appeared. It seems, as if, quite suddenly, the whole earth became newly populated. This fact is nowhere explained in geology. We can only understand it with the help of spiritual science. The latter explains how, in a certain moment, man entered earthly evolution, and in this connection the higher animal world, which is grouped round man, evolved. These animals have warm blood, and man has warm blood; but the temperature of the human blood is much more stable than that of the other mammals. The bear has a stable temperature, but during the whole winter he cools down to 10° C. He lives during the whole winter in deep sleep. This would be impossible for a human being, even for a few hours. There is a great difference between these more or

less stable temperatures in man and animals. The human being must have a certain temperature to remain fully conscious. If the temperature rises or falls a few degrees centigrade above or below 37° C, he is no longer fully conscious. He is either delirious or suffers from under-temperature. There is no doubt that none of the mammals has a warmth regulation similar to men. Still we can say that the different higher animals stand very near man; they also have warm blood, which is similar to human blood, although it has not that constancy in warmth regulation; and these animals are fundamentally different from the lower animal world. In previous times people had a certain feeling for the difference—of course this is not scientific !—and they expressed it by saying, that all creatures which ranked below the birds were "worms." The idea was also prevalent that these worms would arise immediately out of the earth. It was a long time before the idea was overcome that the lower animals could generate from the swamp or from the mud; and before it was found out that there must first be an egg. Of course it was a false idea, and yet there is something true about it, too. The lower animals have a much closer relationship to the earth itself.

The higher animals can only be understood if we consider them together with Man. In the Saurians we have a different world represented. An earth on which man can live and walk about, cannot support at the same time these fantastic creatures, which have arisen from below. The theory of evolution from below is quite justified if we want to apply it to the lower animal species. But we are in difficulties if we want to apply this theory also to the higher animals and man. Considering the lower animals we may think in a straight line from below to above. But if we come, for instance, to the mammals, which are so differentiated in themselves, it is as if we arrive at a tree which has developed a far reaching crown. Man stands in the centre of the upper animal world; the lower animals stand below him, but are also organised into Man himself, where they exist as part of his anatomy. So we distinguish two very different parts of the animal kingdom—the higher and the lower one, the warm-blooded and the cold-blooded. These bloods are absolutely different. The warm-blooded animals are much more individualized. Birds, for instance, are very individual. Frogs, toads and salamanders resemble each other much more closely. A salamander is nothing but an elongated frog. In the more highly developed animals there are significant individual differences, which come into the open most obviously in Man. On the contrary compare these with the army of the Insects ! How similar they are! There we do not find such marked individual differences.

The higher animals are intimately connected with Man, the lower are more remote. Of course we can compare a starfish with a human head, but these differ enormously. It is in a much more distant relationship to the human organism and it is necessary to study the connections in detail. This will be done in the following lectures, when we will find that what is hidden in the most perfect being, is manifest in the less perfect organisms; there it is spread out before us, if we can only see it. We come to that great idea which has been expressed by the great scientist Oken: that Man is the combined animal kingdom, and that the animal world is the dismembered and spread-out human being. Rudolf Steiner had the same idea; but his idea was supported by natural scientific conceptions of the present day and, if Man is considered as a threefold organism, his connections with the animal world become manifest. Oken has only written an ingenious fragmentary conception. It will be unnecessary for us to establish hypothesis; we will look at Man and animal together; Man will always explain the animal, and the animal can give great and powerful explanations of the inner nature of Man. The various phenomena explain themselves mutually if we only collect them. The idea that Man is the combined animal world, and the animal the one-sided development of human qualities, is a master-key for the study of Zoology.

THE AUTHOR

EUGEN KOLISKO, one of Rudolf Steiner's most distinguished pupils, was educated at Vienna University as a doctor of medicine. He was also an authority on the Natural Sciences and History, and was a born teacher. As a lecturer in medicine, zoology, chemistry and history, he was much in demand, both in Europe and America. He died in London in 1939, at the age of 46.

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Zoology for Everybody 2 Birds

Eugen Kolisko

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A Series of Lectures

BY

EUGEN KOLISKO

(M.D. Vienna)

2ND LECTURE

BIRDS

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ZOOLOGY II.

BIRDS.

THIS lecture is dedicated entirely to the study of *birds*. If we look at a peacock

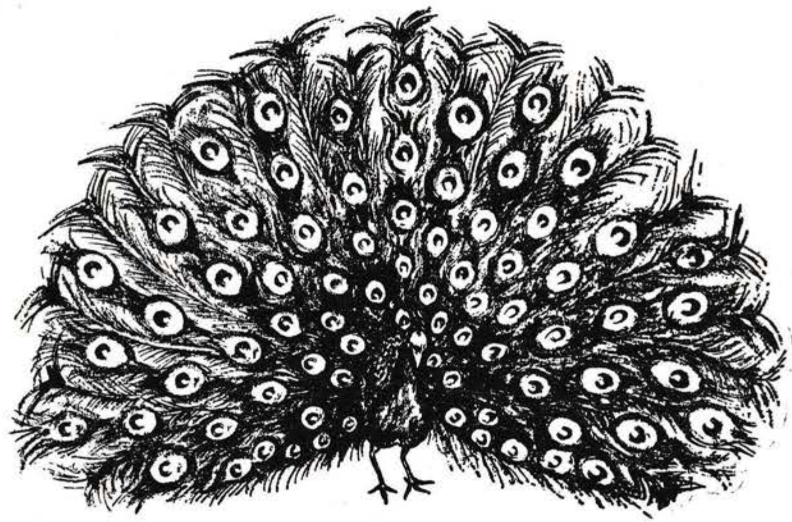


Fig. 1.—Peacock.

we immediately have the impression that we do not only see this bird, but are conscious of something permeated with life, which seems to surround it. We have a similar impression if we watch a big bird of prey, such as an eagle.

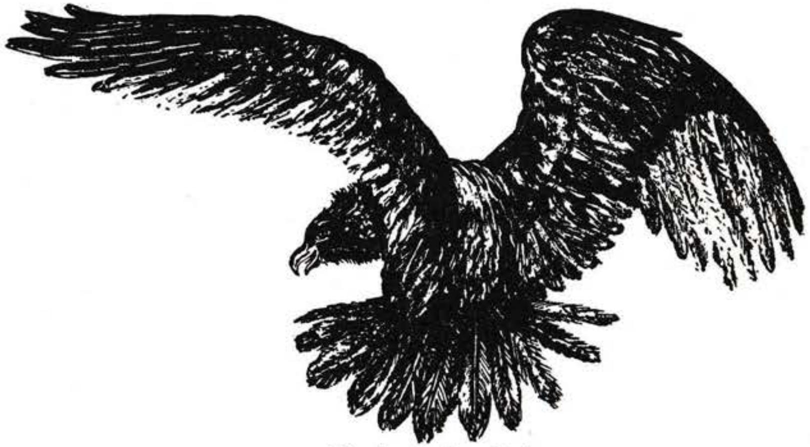


Fig. 2.—Golden Eagle.

The body itself is relatively small, but an enormous strength streams through the feathers into the wings, and even beyond them. The sphere of the bird is much larger than its body alone.

We will turn our attention to the *feather*. It has almost lost touch with the living organism and is no longer in a real contact with the metabolism. Many mineralised substances are deposited in it. It consists partly of horny material and partly of mineralised substances, salts. Some feathers, especially the stiff ones, the wing feathers, produce, when burnt, a large amount of ash, which, in certain cases, shows as much as 50% of silica. It is true to say that these feathers contain such a high percentage of silica, that we scarcely find a similar proportion in any other animal organ. When burnt, they leave a large residue of incombustible matter, and represent a kind of depository for silica. They may show a specific coloration, partly of metallic lustre, and those of the peacock bear strange markings like eyes. We gain the impression that the feathers have developed out of the skin—they are an epidermic growth—yet, they also seem to have the function of a sense organ. The sphere of sensibility of a bird reaches far out into space, far beyond the body, even much farther than that of any quadruped living on land. The feathers only indicate this capacity slightly and are much mineralised and separated from life. The semi-transparent base is the quill; it has two apertures, one at the bottom and one at the top, where the branches begin. (See Fig. 3).

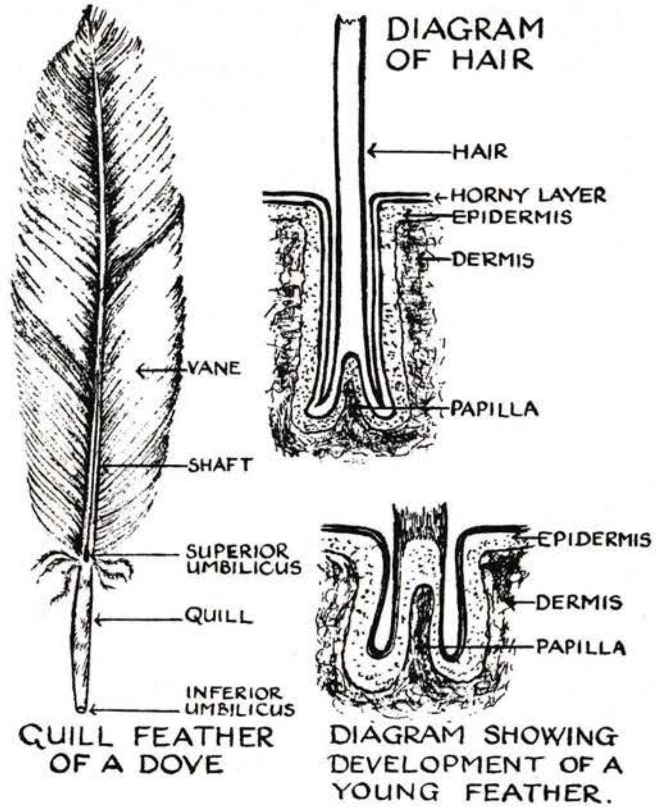


Fig. 3.

At the lower opening the papilla enters to give nourishment, and, if a young feather is taken, the quill will be found full of blood. When the quill is dry and hollow, the feather is more or less a dead thing. Hair, which covers mammals, has a close relationship to the blood and is specially permeated by it in the region of the hair-roots, whereas feathers are more separated from this connection. Of course there are intermediary stages between the mammals' hair and the birds' feathers; for instance in the feather coat of the ostrich, of the Australian emu, or the kiwi,

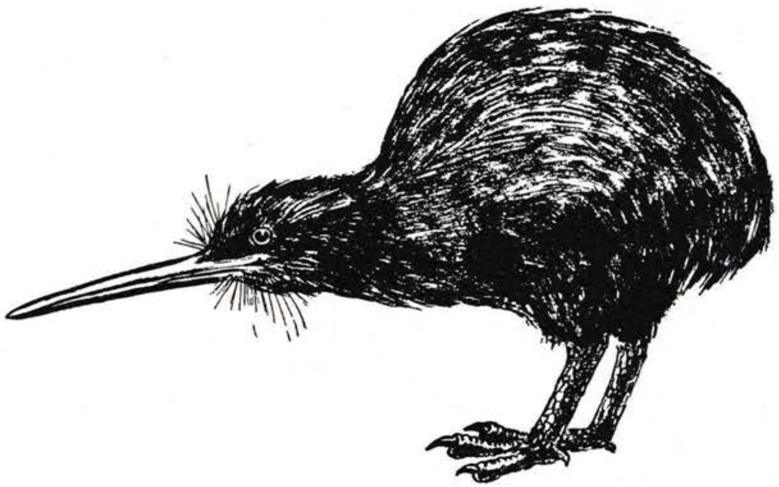


Fig. 4.—Kiwi.

which has no real feathers, but bristles. They are permeated much more with blood. Feathers which do not serve the purpose of flying but of running, are nearer to the earth. If we imagine this process continued we find contraction from the feather to the bristle, and ultimately arrive at the hair, which is formed by a still further contraction. The porcupine represents a transitional stage. The bristles contract still further and at the same time become softer, and then the hair is formed. Thus we might say that the feather is a prolonged hair formation, which has spread out and mineralised. Hair enters more deeply into the blood stream. It grows on a soil which is more permeated with blood than is the case with the bird. Observe a bird and you will see that everything forming the peripheral parts has spread out, become dry, more sensitive, stiffer, and has taken in silicic acid. Although the bird has feathers, it looks emaciated and consists only of skin and bones. The enormous expansion of the feathers sometimes gives the feeling, that something like a mass of vegetation or grass is growing on the bird; we see this in the *ostrich*.

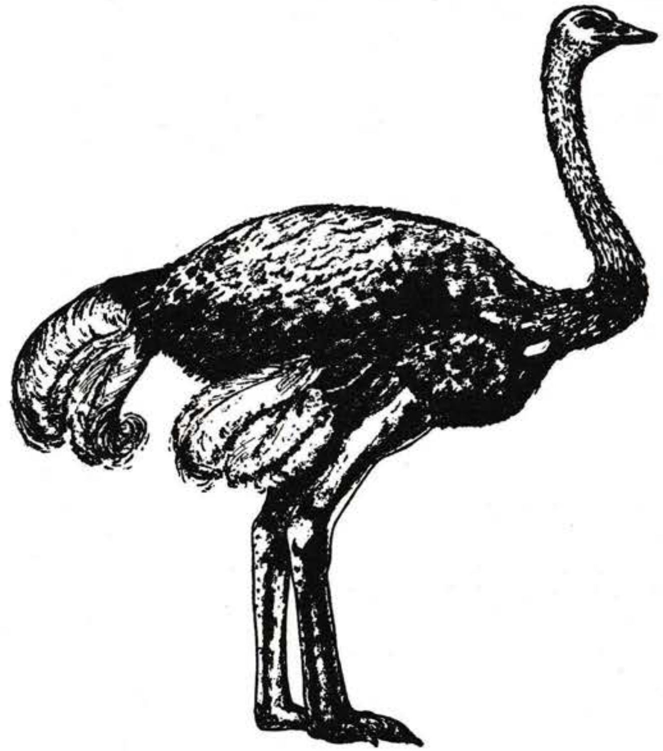


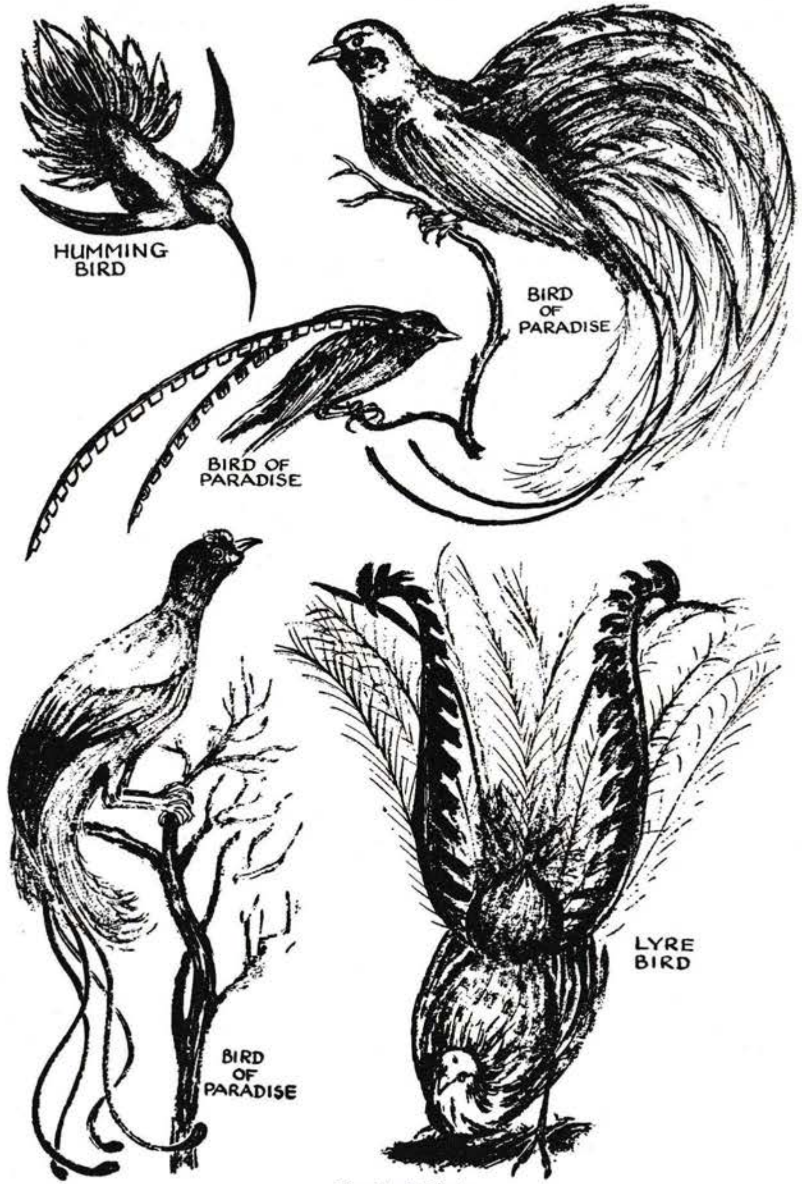
Fig. 5.—Ostrich.

Often we may have the impression, especially when watching tropical birds, that they carry with them a kind of dried vegetation, which has been extracted from the bird organism and has come under the influence of air (see Plate I). The blood can have very little effect upon the feathers.

Birds show, through the fact that their capacity of expansion in the feathers has become so enormous, that they are much more influenced by forces streaming in from outside, which at the same time draw them away from the earth. This makes the whole organism of the bird light.

Let us take another peculiarity of the birds: the *skeleton*. The bones of a bird are different from those of the mammals or

PLATE I.



Tropical Birds.

man. If you study a bird's skeleton you will notice that it is extremely light, and all the bones, especially those of the skull, seem penetrated by air. The same number of bones is there as in other animals, but their structure is different. They are almost without weight.

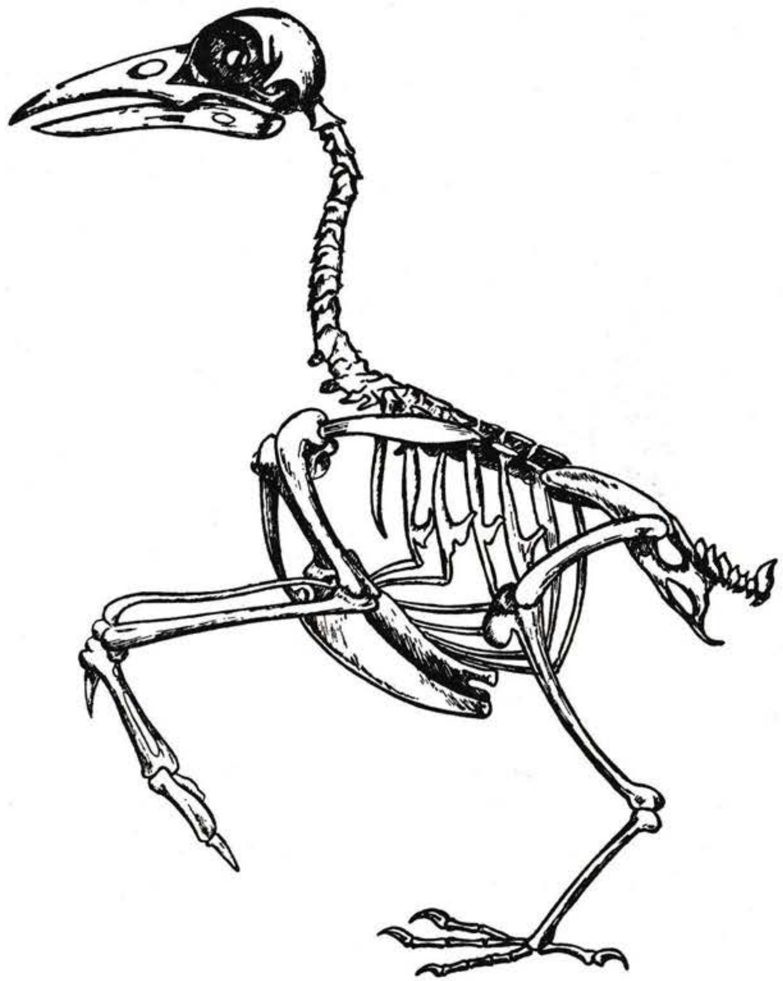


Fig. 6.—Skeleton of a Raven.

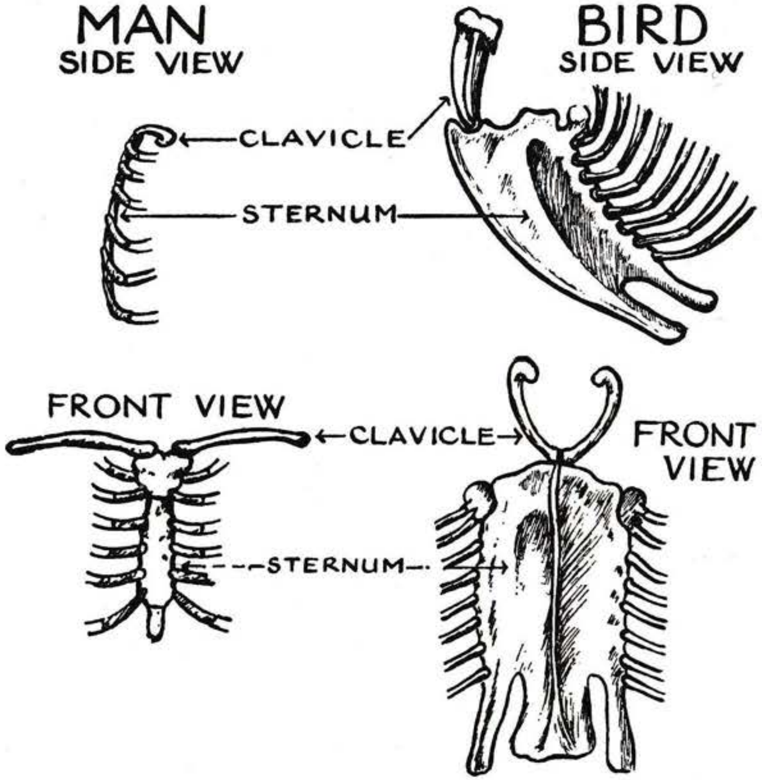


Fig. 7.—Diagram demonstrating the difference between a human breastbone and the breastbone of a bird.

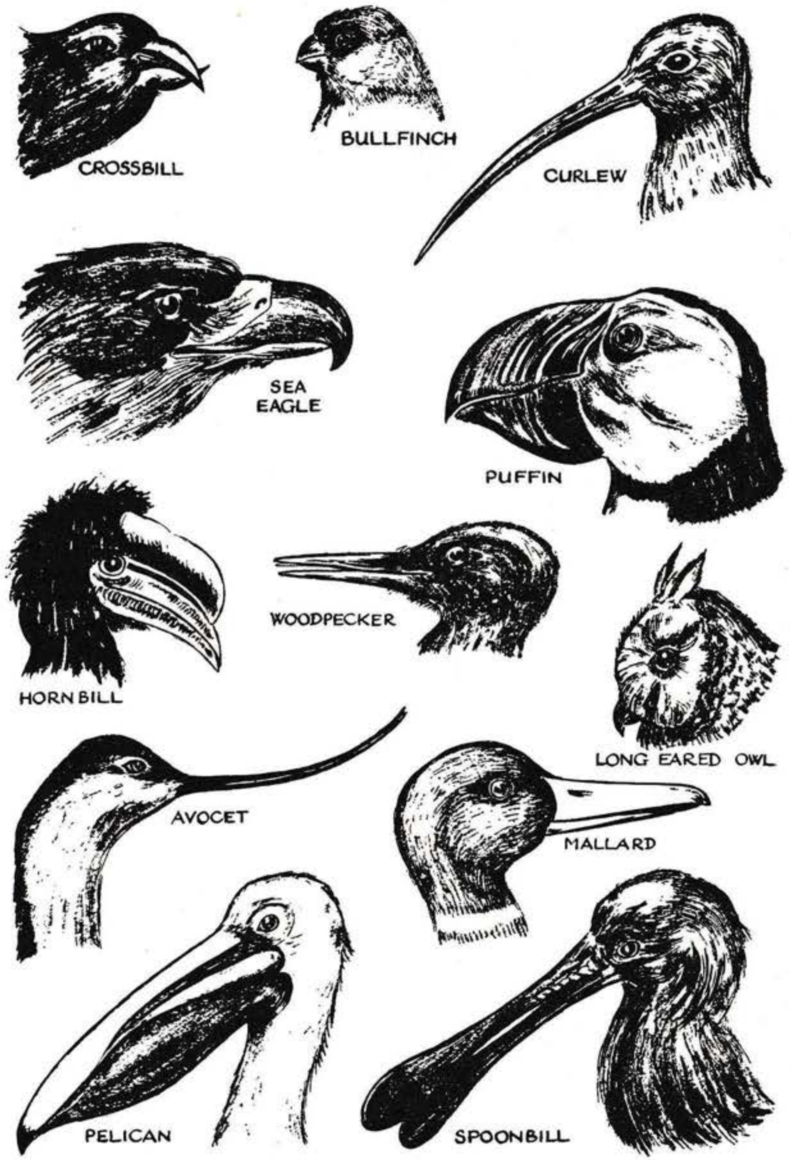
Then we notice that their substance is also different. The bones of birds are whiter and contain more calcium. They are more brittle and more dense than those of other animals. Very early they lose their content of blood and marrow (that part of the bony system which is permeated with blood). The marrow shrinks and its place is taken by a space filled with air. This is not the case with the ostriches. They possess bones with marrow and so do all other birds which run. The better a bird flies, the more its bones are permeated with air. Life in the air makes the bones dry,

brittle and filled with air instead of blood. Neither red nor yellow marrow is to be found in birds' bones.

Studying a bird's bone, we come to the conclusion that it has the qualities that other bones acquire in old age. A bird's skull is a very fragile object. You can easily break it between your fingers, since it is so brittle. The skulls of young birds have some elasticity, but soon the single bones grow together and form an undivided chalice. If we study the skull of a human being we find that until the 25th year the single bones fall asunder. In the bird the bones contract very early. A phenomenon which appears only in old age in all the other animals and in man, appears immediately in the bird. *It has a senile skeleton.* What we consider in man as hardening of the bones, sclerosis, happens quite naturally in birds right from the beginning. But since the birds' bones are so light, it does not matter.

Now we have already found two quite remarkable things: the feathers have their high silica-content, and the horny substance in them becomes more mineralised, than we find for instance in the materials of the horns or antlers of mammals. Thus feathers acquire a more inorganic character; the skin proceeds to something spreading out extensively in the periphery of the bird's organism in the production of the feathers. The silica substance enters there and also the skeleton hardens early. Right from the beginning it looks whiter, and is permeated by air, so that it is hollow and brittle. The two most important parts in the organism of a bird are the feathers and the skeleton. Everything becomes light and gives the bird buoyancy, while simultaneously the organism is hardened.

PLATE II.



Various Beak Formations.

This fact becomes still clearer if we look at the beak (see Plate II), representing a complete hardening of the horny substance. What in other animals we find as calcium in the teeth formation, is entirely absent, and instead, originating from the skin, the beak is formed. The whole face is in a way transformed from the skin into horny substance. Taking such an extreme example as the *Toucan*

Fig. 8.—Toucan

which seems to consist only of a beak, we can see this tendency in its most fantastic development. The horny beak is the only really formed part of the whole face. The head of the Toucan tends to be shaped like a triangle, and this, too, points to an enormous hardening.

The *peacock* shows in a rather extreme way a tiny head, completely hardened, giving us the unmistakable impression that there is not much to be found in it, notwithstanding all the beauty displayed in its feathers.

We proceed to the study of the *sense organs*. Birds develop these to a very high degree. The scientist *Oken* called the birds "sense animals" because they develop various senses exceedingly well: especially the *eye* and the *ear*. The senses of smell and taste are less developed. But mammals especially develop these latter senses in great refinement. Birds are more concerned with the development of their eyes and ears. In proportion to the small head, the eye seems unusually big, even more so if we look at the eye sockets in a skeleton. They are surrounded by a bony ring. The hard skin which is usually formed in the eye, the sclera, thickens to a ring consisting of 12—30 little bones arranged in a circle. The second characteristic feature in a bird's eye is the *pecten* or "fan."

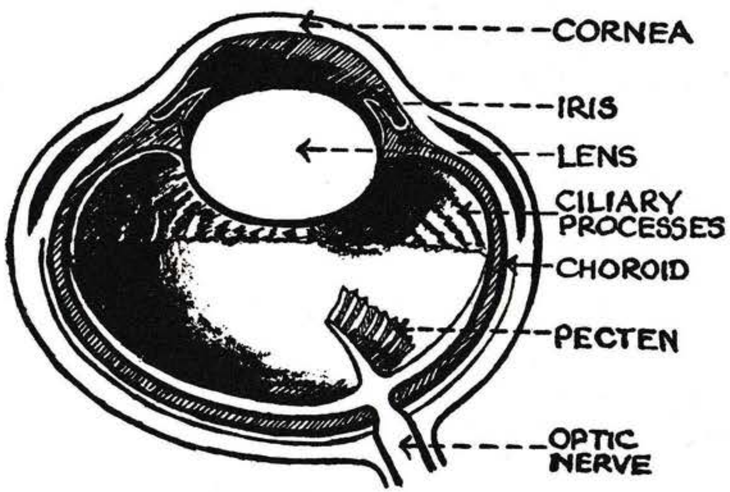


Fig. 9.—Eye of a typical Bird

This is a muscular organ springing from the entrance of the optic nerve, spreading like a fan, well supplied with blood and leading towards the lens. In the human eye it corresponds to the corpus ciliaris, but it is more strongly developed in birds. It makes the eye much more mobile, being so well supplied with blood from the interior, whereas outside it is more hardened. This hardening isolates the eye to a certain extent and thus it can function independently. Everyone knows what extensive sight the birds of prey possess. High up in the sky a buzzard notices a tiny mouse and strikes down instantaneously. We feel that a buzzard or eagle reaches much farther with its sight than any human being ever can.

In the eye of a bird is a much greater limb-activity. Because it is so well provided with muscles and a ring of bones, it acts more like a limb than an eye. It is not only a physical apparatus to receive light, but also an organ co-ordinated with the limb-system. A bird of prey looks and strikes; the activity of its eyes is followed immediately by a reaction of the wings and beak. These activities cannot be separated from each other. We really can say that the eye functions similarly to a limb, through the process of hardening up and the increased mobility and blood supply. The glance of a bird, even of a small one, is piercing. It radiates much towards the outside world, just as we noticed in the feather coat, that something streams further into the surroundings beyond the limits of the bird's physical body.

The *ear* has to be studied together with the larynx. These are independent organs, but belong to each other. The ear can never be used separately, without having the larynx in action at the same time and vice versa. This relationship between the two organs can be studied especially well in birds. They even possess two larynxes, the one situated above as usual, and a second one below in the chest, called the *syrinx*.

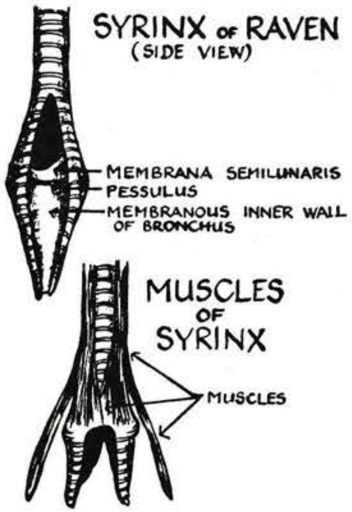


Fig. 10.

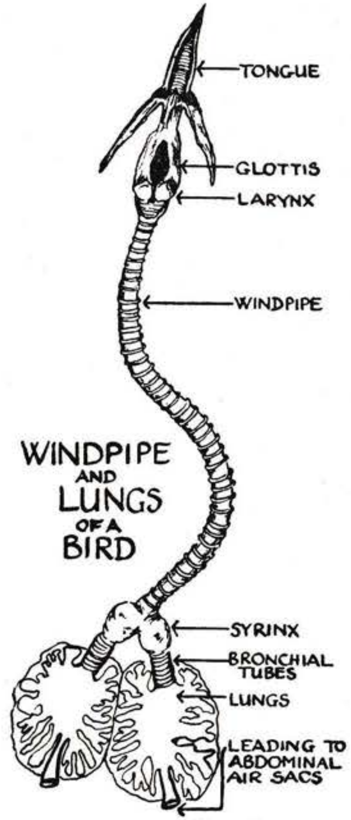


Fig. 11.

The windpipe sometimes describes a loop, descends and ascends again; and below is the second larynx. Then there are peculiar muscles to move the windpipe which lead towards the ear. Singing birds have their song-and-ear organisation closely connected and powerfully developed. But there is no properly developed external ear. It does not open towards the outside world, but turns to the inside. It is strongly linked up with the breathing apparatus; it is more or less interwoven with the whole singing and flying activity.

The eye functions very much like a limb and the ear is linked with the whole organism, more than is usually the case.

Birds have not developed the *cochlea*, instead they have a slightly curved bone to which the name of lagena has been given.

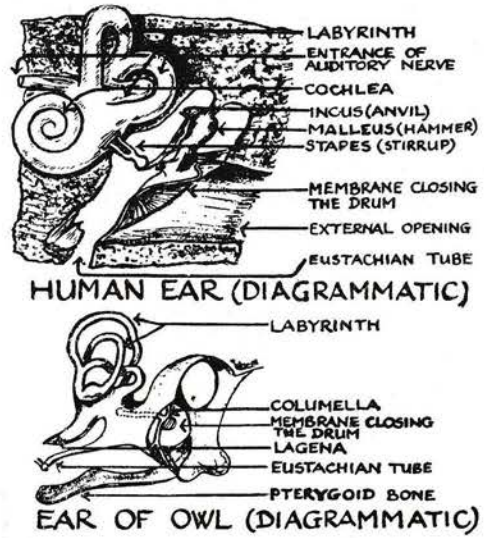


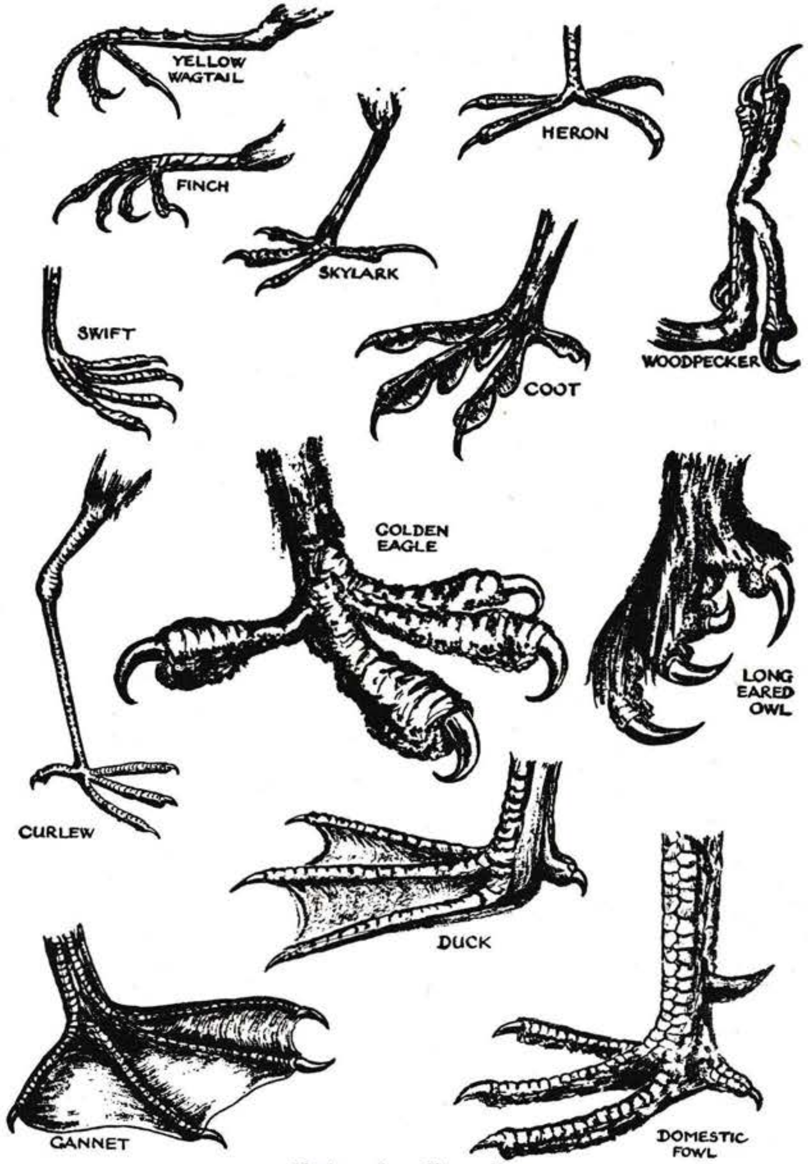
Fig. 12.

The development of the earbones is incomplete. The three bones which convey the vibrations of sound from the membrane which forms the outer wall of the drum of the ear to the inner membrane that forms a window in the bony labyrinth are represented in birds by one bone, the columella.

The organ of Corti is also absent. We may say that this part of the ear is not so subtly built and formed; it has withdrawn more to the inside and is intimately linked to the breathing system.

The sense of *touch* is strongly developed, but has moved towards the periphery. It is embedded in the feather coat. It is not connected with the skin, but radiates out through the feathers in a high degree. We might consider the whole feather coat as a kind of sense organ with which the birds can feel two things: the condition of the air and their own motion. Birds have a marvellously developed sense of *motion*, a feeling for their own movements, especially in the chest region where the large wings originate. The breast muscles are most powerful, while those of the back are not well developed.

PLATE III.



Various Leg Formations

As far as the *legs* are concerned, they are not even completely covered; this makes them look skinny, and skeleton-like (Plate III). The lack of muscles is rather peculiar in birds. All the muscles are concentrated in the breast. There is a terrific strength in the wings of birds of prey, a concentrated strength which consequently must be missing in the rest of the muscular system. The lower parts of the body must be stunted.

The birds are thus very sensitive to conditions in the atmosphere through which they fly; they are attuned to the activity of the winds and air currents. They have an extremely well developed muscular sense, a sense of motion, a sense for their own movements and at the same time a sense of touch. These various sense-functions cannot easily be discriminated. The whole

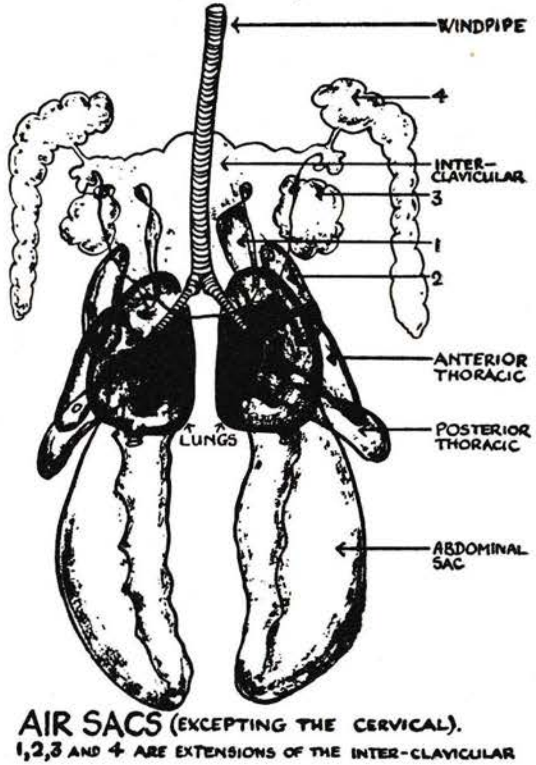


Fig. 13.

consciousness of the bird is in the periphery, outside its organism. We do not get the impression that birds develop those senses which are more directed towards the interior, like the sense of smell, taste or inner life-activity. They develop much more everything directed towards the outside world.

The third remarkable feature in birds is the development of the *breathing system*. Birds have huge lungs, reaching as far below as the belly. The *diaphragm* is missing. From the lungs branch off air-sacs, entering the bones and the wings.

Some of those branches enter even into the feathers, so that the bird is everywhere surrounded and embedded in air. There is, so to say, a metabolism of air reaching even into the bones. The activity of the lungs extends to the bony system and therefore permeates the blood directly. The bird breathes much more vigorously than other animals. It breathes most intensively, therefore it takes much more oxygen into its organism and the processes of combustion are enhanced. That is the reason why it mineralises so many substances, why it deposits so much ash. Internal combustion is so lively, that, as it were, everywhere ashes fly away into its feathers. It is imbued with an indestructible life-process which continually pulverises into mineral substance. Therefore the necessity arises for excessive movement.

Birds have a high blood temperature—about 40°C is not unusual. The pulse is much quicker—similar to man's in his earliest childhood: 120—140 beats a minute. Thus the heart beats quickly.

All these phenomena can be traced back to the intensive breathing. A *cow* also has a normal temperature of 39°C, but this is not due to intensive breathing, but to intensified metabolism. A cow has such a vigorous combustion because the metabolism is enhanced. In birds you may compare this process to kindling fire with bellows. In cows more fuel is present, in birds more respiration. The velocity originates from above and creates the great mobility and a certain restlessness.

The whole metabolism and *digestive-process* must function quickly. The digestion is rather careless. The bird cannot chew with its beak, therefore this process has to be done by its stomach. Those birds which feed on grains possess a stomach (the gizzard) fitted with many horny layers with which they grind the food. The gizzard acts like a grater. Many birds have to eat things they do not really need for food, to keep this grater going. If they do not get these substances, which are mineralised, they perish. The digestion is also an intensive one, for the digestive juices act

quickly. But they need mineral substances, solid substances to stimulate the process of digestion. They regurgitate these again partly as pellets. This is characteristic of their digestion.

The cow ruminates—it has a kind of devotional digestion—but the bird grates its food; it has a more destructive principle and needs mineralised substances to help. It excretes them again, but could not exist without them. The excretion has to be very quick. The kidneys are well developed as are also the lungs. The *large intestine* is missing. Therefore the excretion is not separated into liquid and solid, but is uniform. The bird has so to say, no time to prepare the excretion—it happens continuously. The large intestine represents an organ which began in animals living on the earth. Ostriches alone of all birds possess large intestines.

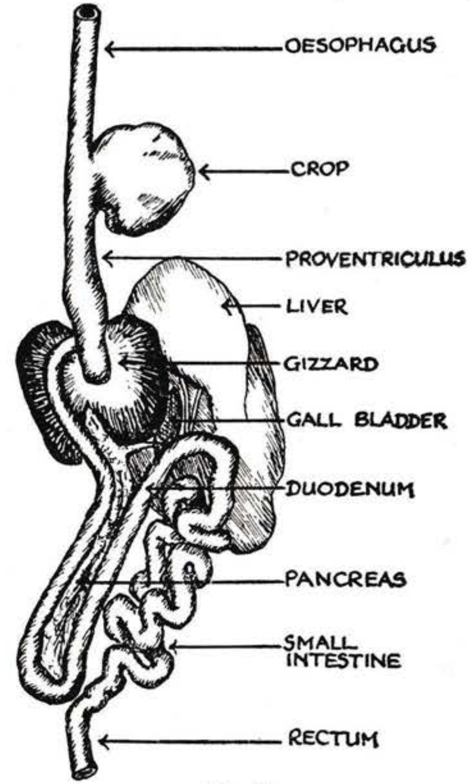


Fig. 14.

It may sound strange, nevertheless it is true, that large intestines may be considered as the legs of the small intestines. When animals began to live on land, they developed real legs, and at the same time large intestines. The true bird has no large intestines. It must have a quick process of digestion, to work with the breathing system. It must eat and pass the food quickly through its body. The metabolism chases through the bird. A similar thing appears in the case of a human being who derives little benefit from his food, because he has to move about too much.

Birds do not get tired easily. Their capacity for movement is enormous. They fly with great velocity, and 50 miles an hour is a moderate speed. Swallows achieve 110 miles an hour quite easily. They can fly many days without getting tired. Why? Because their flying organisation is linked intimately with their rhythmic system. They do not become fatigued, because the heart does not get tired, for they possess a powerful breathing organisation and fly in accordance with the rhythms of the atmosphere. This explains the amazing performances which cannot be found in any other animal species.

We know that the flight of birds is dependent on certain conditions of our planet earth. Some birds migrate and fly during winter to other countries with a definite regularity. They describe specific forms during their flight, for instance triangular forms, and they take their flight over certain districts in Winter. Some fly to southern Europe, some to Africa, some cross the Equator. These routes are fixed. One of them goes right across the Atlantic Ocean. Scientists have made many hypotheses and many theories have been worked out to explain these. A real explanation will only be found, when we form the conception that the birds are exceedingly sensitive to the great atmospheric air currents. The strange phenomenon of migration can be understood if we know that they only fly according to routes having certain ether configurations. They follow the way of rivers. Much has been written concerning the study of migrating birds but it shows the great mistake of looking for the explanation in the intellectual capacities of the birds, attributing much to their small brains. Their intelligence is spread out all over the atmosphere. We do not realise the various changes in the atmosphere, for we are not sufficiently sensitive, but the birds are. They migrate on those air currents where they sense certain ether configurations. They are in unison with the air.

Because a bird is entirely orientated towards the outside world, its inner organism is comparatively uninteresting, for it seems

empty and dried out. We can only understand it, if we think of it as being intimately connected with the periphery of the earth. To live on the earth, a bird would need a more intensified blood activity and all those organs which are linked with life on the earth would have to be transformed.

Now we turn to the *soul-life* of the bird. Everyone who observes birds, remarks that they are more alert than any other animals. They need very little sleep. Some species sleep scarcely one hour in the 24. They can be heard round about midnight and again at 1 o'clock in the morning. Since all their movements are rhythmic, they do not tire easily. Although birds are very much awake, they are very easily distracted. They certainly lack the capacity for concentration, for their inner life offers them no possibility for developing this quality. They are complete "scatter brains." Creatures endowed with feathers cannot really concentrate. Present day science cannot conceive the idea, that, if an animal looks like a bird, it cannot concentrate in its inner life; but it must constantly be diverted by outside objects, it must in fact be "volatile." Singing birds react to every sense perception. They possess a sanguinic temperament, because the air penetrates so deeply into the blood, giving them mobility and such alert senses. During sleep every living organism is regenerated, and refreshed. This is especially true of the human being. The bird does not need sleep for this purpose. It is always in close contact with the whole cosmos, even when fully awake. The human being and all the animals living on earth need sleep, that the cosmic forces may restore the energy used up during waking hours. The bird has a different organisation and is more independent of sleep.

Another remarkable feature in birds is their artistic skill. In this connection we must consider that birds do not produce living young ones, but hatch eggs. They cannot develop in their own inner organism another living being; they are unable to produce the necessary internal warmth in their hardened bodies. Therefore this process must be turned towards the outside. The egg itself has a hardened shell and must be hatched by warmth from outside. While hatching eggs, a hen develops brood-fever, and her plumage undergoes a change. Many soft feathers appear; the strength which usually streams into the feathers is withheld and diverted to the hatching. The eggs of fishes or snakes are hatched by a force streaming in from the outside, the sun. This force is concentrated into the inside of the hen, but it is not strong enough to produce a living organism within her body. No embryo can be formed. The new organism has to be ejected at an early stage of growth, and must complete its development through the hatching process.

The hen is a bird whose privilege it is to lay eggs, just as the cow has the privilege of milk production. One could express this as follows: the hen is organised for the function of egg laying, but the male bird, the cock, has instead the formation of the comb and the more aggressive temperament. We find a similar phenomenon in the bull. The cow concentrates her forces towards the internal function of milk production, while the bull expresses his energy in his head, and in his choleric temperament.

It is interesting to study the process of egg development. The egg needs exactly 21 days to mature. All the various stages are well known; they have been studied over and over again with the microscope, so that every detail has been found. I will mention only a few facts. On the third day the heart appears, on the seventh day the embryo is free and starts to swim in the amnion water. At that time the head has reached the same size as the rest of the body. On the ninth day a hardening process sets in, some of the cartilage turns into bone; on the fourteenth day the heart starts to beat in the normal rhythm, the limbs, first feathers and head are finished, ossification starts and the sex organs are formed; on the twenty-first day the chicken begins to move, the surrounding skin bursts and it leaves the egg.

We might draw a parallel and compare it with the development of the human being; only what means days in the development of a chicken, means years in the human being. What happens to the chicken in 14 days is analogous to what happens in the human being in 14 years. And the 21 days can be compared with the 21 years of human life. We may even find analogies, observing the more spiritual capacities in bird. After 21 days they become bodily free, and are independent individuals. The siskin starts to sing his own song when he is 21 days old. It is said: "They start to compose." A whole science exists about all these facts, but it is not much studied now-a-days. In the earlier editions of Brehm's Zoology many interesting details can be found.

We find similar rhythms in insect life. Bees follow a rhythm of 21 and 28 days respectively. In these animals what happens in days, we find as interesting yearly epochs in human life. I only mention these facts here to draw your attention to the interesting rhythms acting in the development of birds.

Another factor is the marked difference in the sexes. The male birds are much more beautiful and rich in colour than the

female birds. The male sings better. What does this strange difference mean?

The male is more adapted to his surroundings. The feather coat is closely related to the action of *light*. Beautiful colours appear. Everything connected with the senses, with the development of voice and with the capacity of flight, is stronger in the male. This represents the action of light and sound, which enters from the cosmic spheres.

The female bird develops other capacities, such as the hatching of eggs. When the nest is being built, the male bird collects the various materials, the female usually weaves them together. The nest is like a cast of the activity of the birds. The edge has to be made with the beak. Certain parts of the bird's body must fit into the nest, as a cast into the mould. Male and female make the nest together. The male plays the active part, flying about and collecting materials for the female to use. The female lives more under the influence of gravity. Egg formation is connected with earthly conditions. Birds must propagate because they want to live on earth. Their home is where they propagate themselves; apart from this they are not bound to any one place on earth, but are citizens of the whole world.

There is an interesting link between capacity for egg production and leg development in birds. Domestic fowls produce numerous eggs, large in proportion to their bodies, and their legs are very strongly developed. Most other birds, which lay comparatively small eggs, are quite different in their anatomy. The technical terms for the two types are "nidifugous" and "nidicolous," or "insessorial" and "autophagous." All the birds with strongly developed legs, which run about on the earth are nidifugous; they produce large eggs. Those birds which lay small eggs need a nest where the young ones, because they leave the egg in an incomplete condition, may be guarded for some time. These are the nidicolous birds. The birds of prey belong to this group. They must be surrounded by an atmosphere created by their parents. Nest and egg form a contrast. Where there are big eggs, no nest is necessary; but one is essential when the eggs are tiny. Nest building originates in the artistic skill of the birds,* and is linked to the system of nerves and senses; the production of eggs is embedded in the metabolic system. These two activities are in contrast. We can understand that birds have the ability to build nests, because they are not limited to their physical bodies. They over-pass these boundaries in building a nest for their

*See Plate IV.

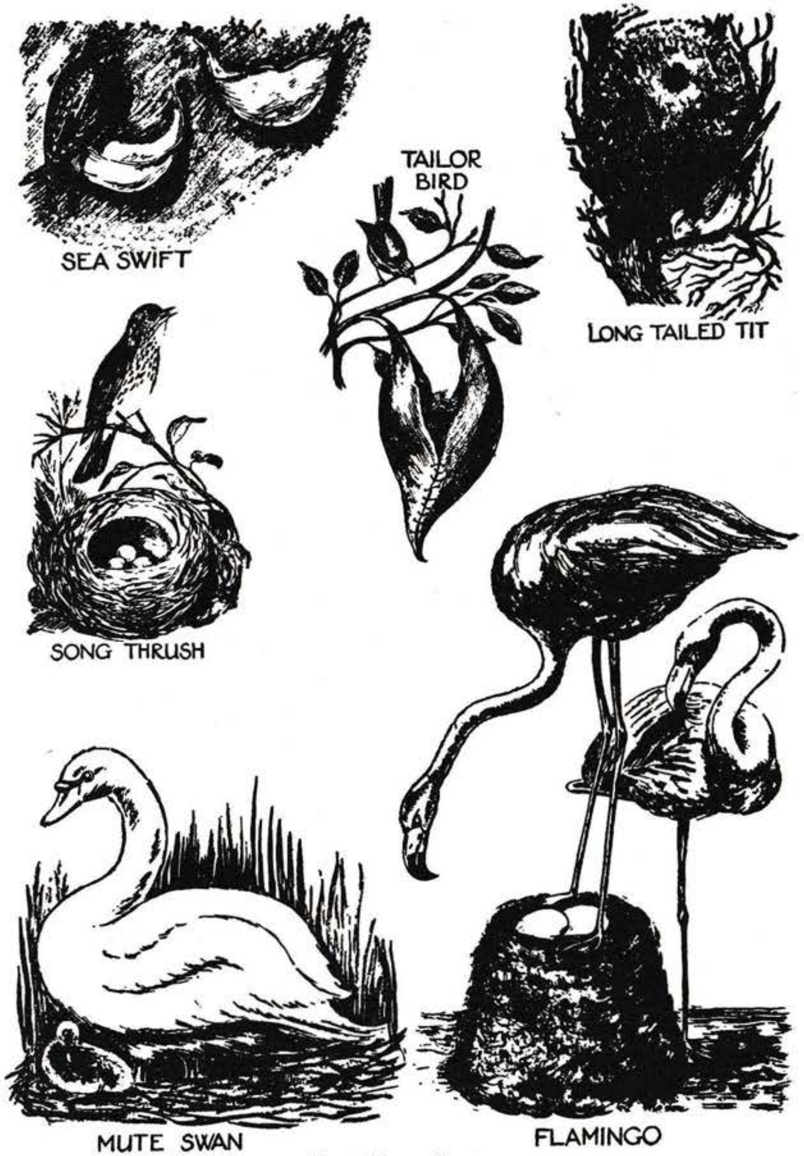
young ones. Make it quite clear to yourself: it could never be expected that a cow would build a nest! The cow includes in her own organism, within the peritoneum, the force which enters into the nest of the bird. The dryness and hardness of the bird is outwardly reflected in the formation of the nest. The more dissociated a bird is from the earth, the more advanced is its power of nest construction. The running birds which are more closely connected with the earth, lack this ability; some make no nests, although they produce huge eggs.

Sometimes people ask: where does this artistic skill arise in birds? What makes the bird so clever? The same forces act in birds when they build their various nests as act in the female mammals, when they develop, inside their bodies, the miraculous embryo.

In running birds these forces have been directed downwards. Consider for instance the contrast between an Ostrich (Fig. 5) with its strong, enormous legs, and a small singing bird, like a thrush (Plate IV) or a lark. In the former we are aware of weight and bulk, force concentrated earthwards; in the latter we see something small and light, but surrounded by cosmic energy. It is in reality an illusion that the singing bird looks so small and the ostrich so big. We must add to the outside appearance the whole activity of the animals, their atmosphere, everything that is surrounding them. We usually do not consider these connections. The artistic skill can be explained by this intimate relation with the outside world. The bird is more or less empty in its bodily organisation and everything tends towards the outside world; there it can build and form, and display artistic skill.

I want to make a few remarks concerning the bird's relationship with man. We have seen that birds develop certain senses to a very high degree, especially the senses of sight and hearing; we have seen how the coating of feathers is built up and we have noticed the peculiar, strongly developed breathing system. The other senses are dimmed down. If we try to compare this with the human being, we can only take the upper part and imagine the lower organisation of man stunted. There is a powerful formation of wings and lungs, and in the head only the middle part would develop as a kind of continuation of the lungs. A bird has a very small brain. It is astonishing that the brain is so small, considering the spiritual capacities. Not only the body, but also the head is empty! It is shocking to observe a peacock, to notice the beautiful plumage growing like a dry vegetation out of th skin, and then the small empty head. It is one of the most stupid

PLATE IV.



Nest Formations.

animals. The whole intelligence has slipped into the spreading tail. There the beautiful metallic lustre catches our admiring eyes —but everything has gone into bodily perfection and nothing has been left over for brain-formation.

In the birds of prey we find relatively more intelligence; still it is a different intelligence from that of a human being. We might ask: where are the forces which usually are connected with the formation of a brain, and appear in human intelligence? They have entered to a great extent into bodily perfections. Rudolf Steiner once remarked that the plumage of a bird is a direct image of thought-formation. Think of a very young bird, before it is fledged, a sparrow nestling for example, and notice how this woolly little creature, with its fluffy covering, straddles in all directions. It looks ridiculous, organically comical. We are reminded of a human being who is naive and, at the same time, in his thinking capacities is not exactly bright, yet full of humour. That is the expression conveyed to us through the plumage of a tiny sparrow.

An eagle is different. There are mighty, powerful thoughts, but only in the form of the beat of its wings. In the realm of birds, thoughts are expressed bodily. Looking with understanding at the various birds, we see the world of human thoughts transformed into organic substance. In a way it is easier to see the bodily connection between mammals and man; that the ruminants are more connected with the lower, metabolic system, the predacious animals with the middle or rhythmic system. It is less easy to say what is developed in birds, which may be compared to something in man, because the breathing system of birds reaches so far into the periphery; what is connected with the brain formation seems to pulverise, and enters into the feathers, so that birds lack intelligence. The flight of birds is the grandest intellectual achievement we can imagine. Slowly we approach this in making aeroplanes. We achieve, by using our intelligence, what is done organically by the bird, and is organically embedded in its organism. Try to study from this point of view the various plumage of birds. Look at a peacock, or a cock, or a hen, or a goose. The stupid goose, with feathers closely packed together is like a way of thinking—an organic way of thinking—which has become dull and obstinate, yet rushes to conclusions without much consideration. The various feather coats are extremely characteristic. It is possible to see in the plumage and flight of birds, much that is enacted in human thought life. Here are habits of mind materialised. Not only the

lungs, the breathing system, but also the nervous system, concentrated in the brain, streams out into the feathery covering There are sparrow-thoughts or eagle-thoughts. The formation of the feathers may be an image of thoughts which have little value, and are short-lived; or which have an eternal quality; and the same is reflected in the flight of birds.

We can classify birds into three main groups.

(1). Singing birds. They are small, and have a subtly built sense organisation. In them we find subtle processes transformed into music, into melodies, into harmonious organic happenings. There is no brain functioning, but a larynx deeper down in the organism, and there they sing under certain atmospheric conditions.

(2). The birds of prey. These are silent birds. They do not sing, but develop above all the capacity of flying. The whole being is centred in the flight.

(3). Running and swimming birds. The lower part is more developed. In a way this is grotesque in birds. In this group we find species with a tendency to extreme thinness, like the storks, or to the other extreme of fatness, like the goose. When birds adapt themselves to life in water they become fat and lose form. An exaggeration takes place, either in length or width; something grotesque appears. They all look like caricatures of birds.

These are the three great groups: singing birds, birds of prey, and those which develop the limb and metabolic system. In this last group we find three tendencies: first the tendency to have large eggs; secondly, disproportionate growth in the legs; and lastly, adaptation of the body to life in water.

There is another group which contains a mixture of all the above-mentioned types. These are the parrots, sometimes also called "winged monkeys" (Fig. 15). They merge the capacity for singing into shrill crying and chattering. They are quite mad. When entering the parrot house in a zoo, it is easy to imagine that one is entering a mad house. Everything seems out of harmony. There are clashing colours and shrieking voices. A parrot can turn its head in all directions, and assume every possible attitude of the body; it can even hang upside down. It is a crazy bird because in it all the three types are mixed. The union of the three produces a similarity to the human being, but in caricature. A parrot chatters without understanding, it imitates the human voice. There is something tragic about it. This bird also reminds us of an ape, which approaches the human being, but does not succeed in the attempt.

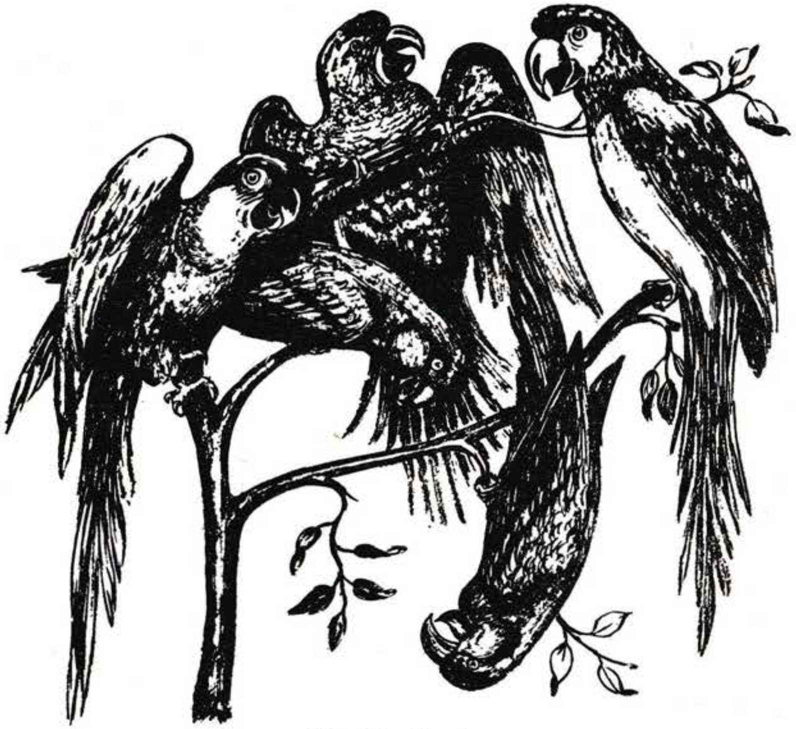


Fig. 15.—Parrots

Of course in addition to the above mentioned three main groups there are various intermediate types. For instance the ravens are between the singing birds and the birds of prey. Some parrots have a tendency towards the birds of prey. Humming birds are nearer to the singing birds, and there are types leading towards the running and swimming birds.

Thus we can divide birds into various groups. But, as a whole we can compare the bird with the upper part of man; or more precisely, with the breathing system and what tends towards spiritual activity in man, which is in birds turned towards bodily expansion in the feather coat. The bird possesses the upper

part of the human organism, but what man has in a spiritual sense, the bird expresses organically.

The bird materialises the spiritual to such a degree, that at the same time the upper organisation of the bird is completely unlike the human form. What is spread out in a bird is contracted in man and transformed into spiritual activity, into thoughts.

We see, in a strange way, the upper part of man: the head, arms and lungs completely transformed and adapted to a life far away from the earth and only touching it now and again. When a bird becomes connected more intimately with the earth, grotesque forms appear.

The bird represents the upper pole of the human organism and has, at the same time, an exceedingly strong relationship to the whole atmosphere of the earth. It has a hardened physical body, and so it depicts the union of the physical with the forces which stream in from the cosmos.

We understand birds if we imagine them as the upper part of the human organism transformed, endowed with wings, and brought into motion.

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THE AUTHOR

EUGEN KOLISKO, one of Rudolf Steiner's most distinguished pupils, was educated at Vienna University as a doctor of medicine. He was also an authority on the Natural Sciences and History, and was a born teacher. As a lecturer in medicine, zoology, chemistry and history, he was much in demand, both in Europe and America. He died in London in 1939, at the age of 46.

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Zoology for Everybody 3

Mammals

Eugen Kolisko

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Introductory Note

Dr. Kolisko intended to write a book on Zoology, incorporating the material contained in his series of lectures given in 1932. This was not accomplished in his brief life.

Soon after his death, Mrs. L. Kolisko published the first two lectures. In 1944 she suggested sketches which might illustrate Lectures 3 and 4, on the Mammals. She was very occupied at the time, with the preparation of the first edition of "Agriculture of Tomorrow" and many other tasks. Translations of Mrs. Kolisko's shorthand reports of these two lectures were only completed recently. They are presented here for the first time.

G.A.M. Knapp

Stroud, February 1979

List of Illustrations

ZOOLOGY III

MAMMALS
a general survey

Let us begin by looking at life as a whole in this animal group. Later on we will proceed to a more detailed study of the various species.

The mammals differ from the birds in that they are more confined to a life on the earth, on solid ground. They are the most perfect animals. When speaking about "animals" we always have the mammals more or less in mind. They are the most characteristic feature of the animal kingdom. The name "mammal" indicates the special peculiarity which distinguishes this group, that is the method of reproducing and feeding their offspring. This group comprises all the warm-blooded animals with the exception of birds; that is all the animals which do not lay eggs, but produce living young ones, which they nourish by suckling. This is a special way of producing and caring for the young, and we will begin with this part of animal life, studying it from a wider point of view than is customary.

The way in which birds reproduce their species, by laying eggs, is a process strongly connected with the outside world. The egg is laid by the female bird and is hatched from the outside. I wish to mention once again that the lower we descend into the animal world, the more we find conditions similar to those of the plant kingdom. In the plant world outer factors contribute to the phenomenon of producing seeds, from which new plants develop. The forces of the sun and those of the earth, of the surrounding soil, contribute to the process of reproduction in plant life. We find similar phenomena in the lower animals. In the fishes we see that the forces of the sun must help in the ripening of the eggs, in bringing the next generation to full development. The reptiles and snakes also need the direct action of the sun for the hatching of their eggs. Here the forces of the cosmos must always play a prominent part in the regeneration of animal life. This is not possible from within the animal organism, without such assistance from outside.

The birds have a greater inner strength than the fishes and the reptiles. Birds, after having surrounded their eggs with shells of lime, and then laying them, can hatch the eggs with their own bodily warmth. The hatching is done with the warmth of their blood.

This "hatching" process becomes more and more an internal one in the case of the mammals till living young ones are born which have developed inside the female body so in the various species of mammals, we find that this process becomes more and more an inner one. The production of young ones enters more and more deeply into the maternal organism, into the blood organisation. It would be possible to show, in mammals, a process leading gradually to an intensification of the inner life.

There are some animals, the Australian Marsupials, which are considered to belong to the mammals because they suckle their young ones. They are born incomplete, and finish their development in a pouch, which is formed inside the skin of the female. They represent an intermediate development between animals which hatch their young ones and those which give birth to living young animals. In Australia especially we find a rich fauna of animals which develop their young in a pouch. On this continent animals have only reached the stage of pouch-bearing species, like the Kangaroo. There are many species of animals in Australia, but they all appear in this typical form. There is a pouch-wolf, a pouch-rat and a fox-like species. We can find nearly all the various animal species, but in an edition of pouch-bearers. We are impressed that the forms which are produced by the animals seem to be independent of the material from which they have to be built. This is an important fact; the forms are independent of the material. We are sorry that this idea has not yet entered into the study of our present zoology and botany.

FIG. 1 *Kangaroo and young*

For example, when studying the plant kingdom, we may observe that a certain species exists in the form of a tree, a tree such as we are accustomed to find in our forests. But exactly the same tree-form may be found in the sea, as free floating seaweed, like a movable tree which floats in the sea. We may study various mosses and there again find minute forms which are similar to trees and bushes. At various levels we find, again and again, the same form built from different materials.

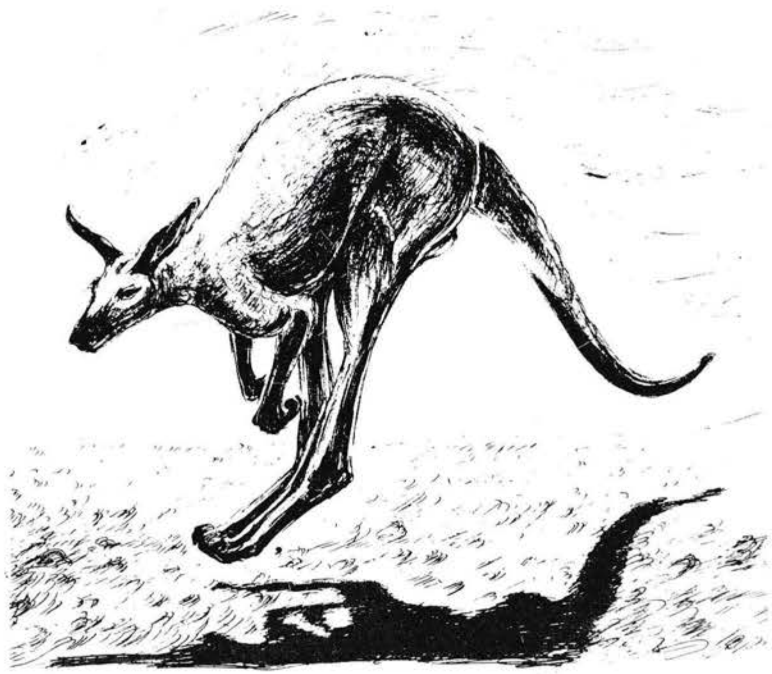


FIG. 2 *Kangaroo jumping*

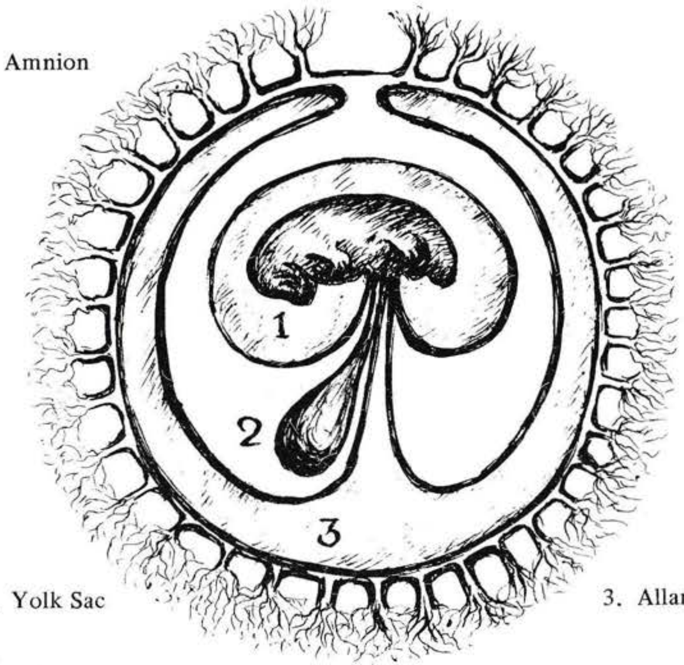
FIG. 3 *Duck-billed Platypus on land*

FIG. 4 *Duck-billed Platypus swimming*

This is also true for animals. Thus we find a complete range of mammals, but all on the level of pouch-bearers. The process of reproduction is not yet so far developed into the interior of the animal; it stops at an intermediary stage between bird and mammal. These animals cannot fly but they can jump. We have an intermediate condition between laying eggs, hatching the young ones, and a more internal development. The Australian continent has been separated early in world evolution from the other continents. This is the reason why we do not find the higher mammals in Australia.

For example, there is a peculiar animal, the Duck-billed Platypus. It has a hairy coat, a fur-like covering like a beaver, to which it is similar in size. It has a beak like a bird. It lays eggs, and later on, suckles the young ones. Here we see that all the phenomena meet in one animal species. It is really an intermediate form of animal. It lives only in Australia, *the continent of intermediate animal species*.

1. Amnion



2. Yolk Sac

3. Allantois

FIG. 5 *Diagram of Placenta of Mammal*

The true mammals, if we exclude the strange animal world of Australia, are those which can produce completely developed young ones inside their organisms, which can be born alive. After birth, they are suckled. The process of milk excretion begins in the mother; blood is transformed into milk. This is a very subtle inner process and in the animal world the process is found only in mammals.

We observe that some mammals can produce many young ones at the same time. For example, mice are very prolific. But there is a limit to the number of young ones which can be produced simultaneously. More than twenty-four can never be produced at the same birth. Mammals with a long gestation period have smaller litters. Those needing six months or more for the embryo to develop are usually limited, on the average, to one young one. Here again there is a certain limit.

A special organ, characteristic for these species, is created to provide for the nutrition of the embryo over a long period. This is the placenta, from which the embryo can be supplied with blood. It is a round flat organ within the uterus which establishes communication between mother and child, by means of the umbilical cord. The placenta is a circular mass and from its centre are radiating blood vessels entering the embryo. The uterus in the animal kingdom is an organ found only in the mammals. What has been acting from outside in the lower animal kingdom has now entered into the interior of the mother's organism. It is interesting to observe these radiating vessels entering into the embryo. As we do so, we are reminded of a picture of the sun and the moon. This is not astonishing because, in a way, the placenta acts as the sun does in the kingdom of the lower animals. Similar forces must be hidden within this inner organ, the placenta. We follow the development of the embryo in mammals by calculating in moon-months. It is warmed by the blood streaming through the peculiar, circular, radiating organ, the placenta. We may suppose that the same forces which act from outside in the reproduction processes of the lower animals are here acting, but from within the maternal organism.

Reproduction is always linked to the moon rhythm; fructification is also connected with the moon. Ripening of fruit depends on the forces of the sun. In mammals we observe the development of an embryo, and the formation of the placenta. Furthermore, we notice that the more highly developed mammals are, the more intimate is the connection between placenta and uterus. The more closely these are connected, the more difficult birth becomes. We can notice this when we study the apes.

A much stronger connection still is found with the placenta or "after-birth" in the human organism. There is an immense difference in this respect between human beings and the other mammals. The process of birth becomes more and more an internal one, but at the same time it also becomes more complicated and more painful. There is a much stronger organic connection between the maternal organism and the child, as well as a soul-connection between them.

In other mammals the link is not so strong. The lower down in the animal kingdom, the less the connection becomes, until finally the organ ceases to exist altogether. We can really observe how the whole process of regeneration comes from outside, and enters more and more deeply into the organism. It enters completely into the blood of the mother. We might even compare this strange connection between uterus and placenta in mammals and human beings with something else: that is, with another building process, that of the heart in a living being. A specific extension of the blood circulation is created towards the embryo. The whole process is taken over by the blood. What has been achieved before, from outsids, through the cosmos, in the kingdom of the lower animals, contracts towards the inside in mammals.

If we look from such a view point at these processes, it will be clear to us that such important phenomena as the birth of higher mammals brings into action forces from within, which otherwise are spread out in the universe. We shall never acquire a real understanding of the process of reproduction, least of all of occurrences in embryonic development, if we study them only from an earthly standpoint. Also this process cannot be understood only from the interaction of the two sexes. Special organs have to be created which are able to attract the forces from the periphery and gather them inside the maternal body. The female organism has a very strong connection with cosmic forces, which are united with the development of the embryo.

This process becomes a more and more inner one, and is taken over by the human blood, or we could say: by the human heart.

It is important to study these things carefully. It is not sufficient to look at the difference in the soul-part only of animals and human beings. There are corresponding facts entering deeply into the organic structure. Human beings have a peculiarity for which there is no comparison in the animals. This is the difficult process of human birth. This is because the organic connection is so strong; Man is born out of the mother's womb with the greatest difficulties. This also explains the different relationship of mother and child after birth, compared with the relationship between animal mothers and their offspring.

The process of milk production in human beings is much more subtle and more intimate, right down to the chemical constitution of the substance produced.

Here we have the distinguishing characteristic of the mammals: the nutrition of the embryo by the blood, and, later on, the feeding of the young ones with milk produced from the blood. At first the placenta pours blood into the embryo from below, as nourishment. Later on, after the birth and the first breath, the young one is fed by milk. The organs for milk production are placed higher in the body of the mother, the higher the development of the mammal. In the ruminants, the milk-producing organs are situated deep down in the body. In other mammals they are placed higher, until we see a great difference in position when we arrive at the human being. The lower connection is the more intensive one; the upper is lifted more above the purely organic. The differences between human being and animal are very great in this sphere.

Blood contains iron, not so milk. Milk has been produced out of the blood, but it has been transformed enormously and has changed from an animalic liquid to one more plantlike. Milk is a food which can nourish all the various organs, whereas other foods nourish only certain ones. That is the great difference between milk and any other food. Each animal species has a different milk, which has a quality belonging only to that species.

Thus the distinguishing characteristics of the mammals are: a true embryonic development which is prolonged as the perfection of the species progresses. Secondly, we find that the blood circulation branches off and enters into the reproduction process. Finally, we come to the production of milk, as a complete transformation of the blood. In the mammals, blood plays an important part. In the birds it is not so. The mammals are really formed out of the blood organisation. In them it becomes so important for in it are hidden all the various characteristics of the species. This is not so much the case with the other animals.

The lower we go in the animal kingdom, the more we find that the blood loses its characteristic red colour, and changes into a colourless liquid: the lymph. Blood evolved late in animal evolution, as it does also in embryonic development. The same is true for the formation of the heart, which also evolves relatively late. Ernst Haeckel was aware of this fact. The blood is young in comparison with the rest of the organism. It is a kind of mother-substance for other organs. It is constantly in the process of "becoming." Out of the blood arises the placenta, which is a kind of heart situated lower down in the body. It is as if the blood creates a peripheral heart. The placenta can be considered a peripheral heart enveloping the embryo, a heart which is turned inside out, and within which the embryonic heart finally evolves.

In Man, the heart only reaches its completely human form, with its four chambers, at the first inhalation after birth. Only at the very moment when the child is born is the heart completed. It is the last organ to become complete. At the moment when the peripheral heart (the placenta) ceases to function, the whole process is turned towards the centre of the newly-born being, and from then on is activated by the human or animal heart. It is as if the system of blood circulation is rebuilt in the embryo.

We speak of a bird-embryo, but this is not a true embryo. If we examine an egg, we find that the yolk is underneath the baby-bird. The bird-embryo has the same relationship towards the egg yolk as the mature bird has towards the earth: *it flies away from it*. The embryo is outside, and it absorbs the egg yolk into itself from outside. The mammals use the egg yolk from inside, and quickly change over to placentary circulation. The latter forms the real embryo, and the yolk sac is soon destroyed. We see clearly how differently embryonic development proceeds in the birds and the mammals. The difference is still more obvious in

Man. It is an inner process, right from the beginning, enacted from the forces of the heart and spirit of Man. The embryonic development is achieved with an immense intensity from his innermost being.

The bird embryo however cannot be considered a true embryo, like that of the mammal.

Mammals are strongly linked with the blood; they are, as it were, creatures of blood. The birds are creatures of air rather than of blood. In them the periphery takes a more active part. Birds are more permeated with the air element. Their breathing is rapid and they fly. Both these processes are linked to the breathing system. The bird is strongly influenced by the outside air. In mammals it is the blood within them that is the important factor. The blood is active in the forming and configuration of the animal.

In most cases, with a few exceptions, mammals have a hairy covering. What is the difference between a hair and a feather? A feather is a skin-horn product, which has been modified by light and air, and therefore acquires beautiful colours of metallic lustre, with interesting markings on them. These qualities are derived from the outside forces, though, of course, hereditary forces also play their part. The feather is, as it were, a hair which has been lifted out of the metabolic process. A hair may develop into a bristle. Then it may branch off in various directions. Just as a plant, growing under the influence of the sun forces, produces a stem from which leaves appear, so an animal organism, which becomes governed by light and air will tend to develop a coat of feathers. Among the Ostrich Family for instance there are some rather grotesque species, there is the bird with bristles: the Kiwi. When it is very young, this strange bird is covered with hairs. All the running birds have a tendency to be affected more by the earth. Their metabolism is stronger and their feathers tend to change into hairs.

The pelts of animals are much more strongly permeated with blood. Feathers are an important part of a bird's organism. Strip a bird of its feather covering, and it looks grotesque! If a feather could be drawn more into the interior of an organism, and more fully supplied with blood, then we should arrive at the hair. Hairs are rooted more deeply into the blood system than feathers.

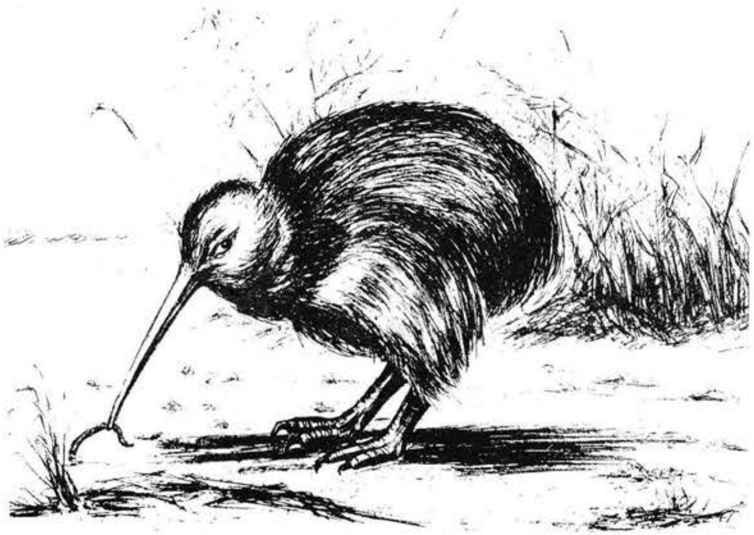


FIG. 6 *Kiwi*

FIG. 7 *Polar Bear*

As far as hair is concerned, Man is again very different from the animals. What is spread out all over the animal's body, contracts in Man and appears mainly only on his head. It is interesting that red hair has a greater percentage of sulphur, whereas black hair contains more iron.

Let us now study the various colours appearing in mammals, and compare them with the colours found in birds. All mammals have brown mixed into their colours. Mammals living in Arctic regions, or in snow-covered countries become white. Others are black, or reddish, or yellowish, but mingled with all these colours somehow brownish tints appear. Brown is, in a way, the colour of the earth itself. Most animals are adapted to the earth colour because they must protect themselves. This brown is produced by the interference of the blood; the pigmentation is derived from the blood.

The colours of birds are different. They resemble more those we find in flowers. Still more, they are similar to the brilliant tints we find in butterflies. Glowing, metallic colours are dusted upon their wings from outside. These do not have a strong connection with the blood, nor are these tints related to the blood chemically.

Colours vary according to the climate in the case of animals. This is not due to direct influences from the surroundings. It is not true to say, for instance, that the Polar Bear becomes white because it lives in a snowy landscape. The pigment is produced from the blood, out of the inner organism, in correspondence with the environment. If we understand that what is outside mammals enters into their blood, then it is apparent how such phenomena as changing colour in summer and winter appear. These changes are produced by a reaction in the blood, which adapts itself to the changing outer conditions of the seasons. As long as we do not understand that the cosmos enters into mammals, as it were, then we can never explain these various processes. It is exactly the same with the colour of skin or fur; what is outside, has entered into the animal. For example, if we breed fishes in an aquarium which is standing on a white surface, then the fish become white because of a transmission via the nerves-and-senses system. This phenomenon does not occur if we blind the fish. The effect from the outside surroundings is transmitted through the nerves. In mammals it is through the blood, not through the nerves, that colours are produced. It is the blood stream which is responsive to the conditions in the various regions of the earth. These animals are formed by the earth, into which cosmic influences radiate and then stream out again.

That fruits ripen in autumn is due to the fact that sun forces, active during the summer, are then reflected back from the earth. In the case of animals it is the same in a more organic way.

The whole of embryonic development is based on the fact that something is reflected, from the inside, which otherwise only acts from without.

By studying the embryonic development of mammals, and also the production of their coverings of skin and fur, we gain a real understanding of them. It is the blood-circulation which makes the animal have insignificant greyish or white fur during the winter. Each winter the animal becomes "old" and its hair becomes white; each summer it becomes young again! Man is different from the animals. His hair, confined to the head, corresponds to the complete fur coat of the mammal. Man has a definite individual hair colour, which lasts until he becomes grey in old age. In animals, we find that the colour ceases to change with progressing age. Finally the winter colour becomes permanent.

In animals, mating and breeding is entirely dependent upon outside circumstances, on changes in the seasons; it is different for the various species. The animal is responsive to outside influences. Man has emancipated himself from these and has his own rhythm. It is by freeing himself from direct cosmic influences that he becomes Man. If he comes under certain cosmic influences again, it is a form of illness.

Having studied the various effects due to the action of the blood, we will now proceed to study the skeleton. The skeletons of mammals consist of more or less the same bones as those of a human being. One characteristic feature of the mammals is in the formation of the teeth, with the exception of the Marsupials, the sloth and the duck-billed platypus, which are "intermediate" animals, not completely mammals.

The mammals have a certain fixed number of bones. A snake has many vertebrae and ribs. There the number of bones is not

yet fixed, because we may find in one and the same species animals with more or less vertebrae. Also in fishes the number is not yet constant. Even in birds we find variations. The vertebral column in Man consists of a given number of vertebrae, and it is a very rare event to find that a human being has a vertebra too many or that one is missing. In Man it is characteristic that the number of his bones is fixed. This fact is slightly indicated already in the mammals. For example, all mammals have seven vertebrae of the neck, the same number as Man. But there is no consistency in the number of tail vertebrae. The whale, the mouse and the giraffe each have seven cervical vertebrae. The difference is only that those of the giraffe are very long and those of the mouse very small, but there are always seven. The bones of the skull are also equal in number. It seems as if a normalising influence starts from the head. In the chest region the differentiation begins. We find still more differences in the number of bones in the limbs. In mammals the fixation sets in from the head and becomes loosened the more we approach the tail. The bones in the skull are limited to the definite number, and certain bones always appear, however different the form of the skull may be. We are reminded of Goethe's publications about the intermaxillary bone. The whole animal physiognomy is determined by the formation of this bone. In the human skull it seemed to be missing. Goethe formed the opinion that this could not be so, and at last discovered the existence of this bone in the human skull. In the animal skull the incisor teeth are in the intermaxillary bone. It has a specific form, for example, in the hippopotamus, in a tiger, a beaver, a monkey, and it also has a definite form in man. It is only a peculiar fact that in the human being this bone has withdrawn and melted into the maxillary bone. It cannot be found outwardly. Goethe had the courage to assert: "Even if the intermaxillary bone cannot be found in Man, it still must exist, only it is so much withdrawn that it disappears into the maxillary bones." If, in the human being, this bone protruded, an animal physiognomy would appear. Man has the same structural plan as the mammals, but it is arranged in a different way. The intermaxillary bone is an important part of the facial bones, and man must have it, but he withdraws it into the interior. The incisor teeth are also not so prominent in the human being, as in the animals. Man withdraws them, too, and

FIG. 8 *Hippopotamus*

builds an harmonious semi-circular arrangement of teeth. He builds a human jaw. He does not allow the incisors to prevail, as the rodents do, nor the canine teeth as the predacious animals do, nor the molars as in the case of the ruminants.

The development of nerve-anatomy resulted in wiping out, more or less, the differences between animal and Man. It is, of course, important that the same bones may be found in animals and in Man. But it is of still greater importance that they are arranged in a different way.

To a certain extent the skeletons of animals are determined and fixed, but, on the other hand, the proportions vary exceedingly. Thus the giraffe has long cervical vertebrae, the mouse tiny. The number is fixed, but the form varies. Only in man is complete stability achieved, and it seems quite natural to us that he has seven cervical vertebrae, twelve pairs of ribs, twelve pairs of thoracic vertebrae, five lumbar, five sacral and four coccygeal. Man has a proportioned organism in contrast to the unproportioned animal body. This fact becomes immediately clear if we observe the following animals: the hippopotamus, which has a characteristic form which seems distorted and

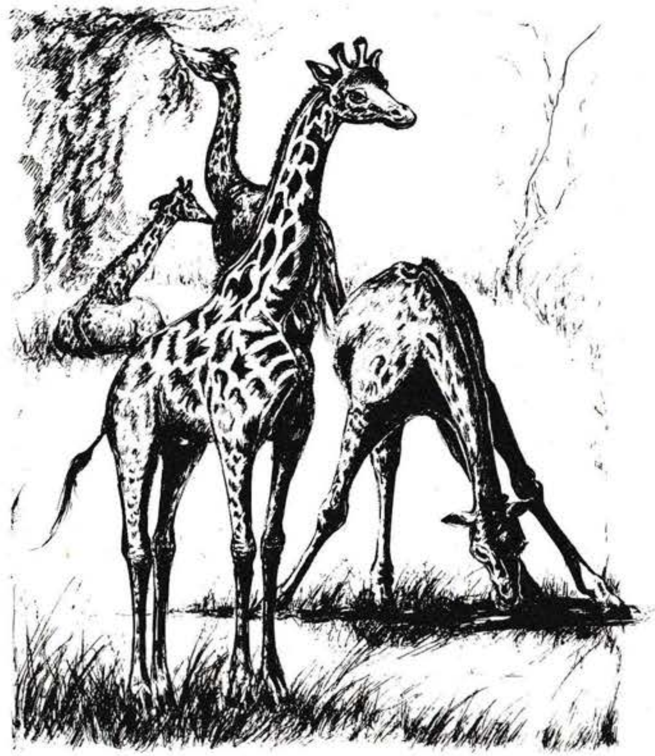


FIG. 9 *Giraffe*

FIG. 10 *Ibex*

unbalanced. Then the ibex has parts which appear to be elongated. All the animals which have antlers seem to have parts of their bodies disproportionately elongated. In the tiger, by contrast, everything is compact, parts seem to have contracted and shortened.

Teeth, which are a part of the bony system, are extremely characteristic for the animals. Once it was customary to learn the various formulae for teeth formation. It is possible to learn much about the whole character of the animal by studying its tooth arrangement. It may tell us something about the skull formation. An animal may develop the molars and have a gap in front, like the ruminants. The main stress may be laid on the development of the incisors, as in the rodents. The teeth may be formed as in the horse. The horse skull has very little development in breadth. It is completely adapted for the forward direction. The horse can run in a certain direction and also looks towards a certain point; it has to have blinkers. You need only study the head of a horse to know much about the whole character of this animal. It is formed perfectly, but in a one-sided manner, and is terribly hardened. The tiger has powerful canine teeth. The skull structure shows that there is much room for the prey he devours. The skull of the hippopotamus shows an extraordinary wide, uncouth, but powerful formation.

The formation of the bones is so characteristic in animals. We may study the skeleton of a cat and find the seven cervical vertebrae, then twelve pairs of ribs followed by a great number of lumbar vertebrae. Each cat has a different number of vertebrae of the tail. Wherever in nature we find variability in numbers, it is a sign that there are still vegetative characteristics existing. Plants also have no fixed number of leaves. The back part of the animal is indefinite, the front is determined. In the front part of the animal formative forces are acting which vanish towards the back.

We do not find this phenomenon in human beings. By turning from the horizontal direction, still kept by the animals, into the vertical line, and thus becoming upright, Man reaches a certain perfection and completion. However the coccygeal vertebrae in human beings still vary in number. These, and the last rib are examples in Man which can still show variations. If we find additional ribs in a human being, we call these "signs of

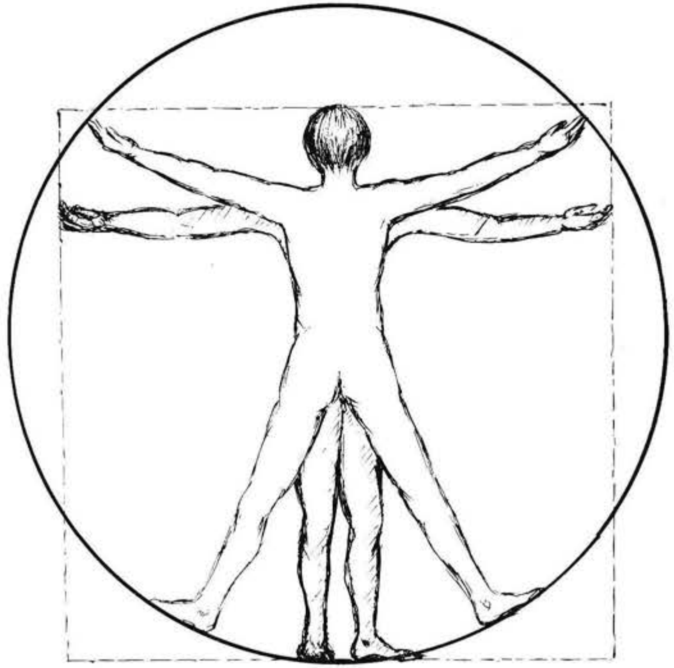


FIG. 11 *Proportions of human figure in relation to circle and square*

degeneration." It is a returning to former conditions. These atavisms are present that we may conquer them. It is very important that we find that there is a definite law which lifts Man out of the animal kingdom, still a very tiny tail is preserved. That is very interesting, that Man has conquered everything, but with one little exception. During embryonic development we also find a kind of tail which disappears again, later on. Only the coccygeal bone remains and enters into the human form.

Man has certain rhythms of numbers inscribed into his skeleton. It is not mere chance that by placing man in this position, a complete circle can be described, connecting head, arms and feet. This could not be done with a horse!

If we take the measure of the hand, we find that the arm is exactly the length of three hands. The leg is four times the measure of the foot. The length of the vertebral column of the

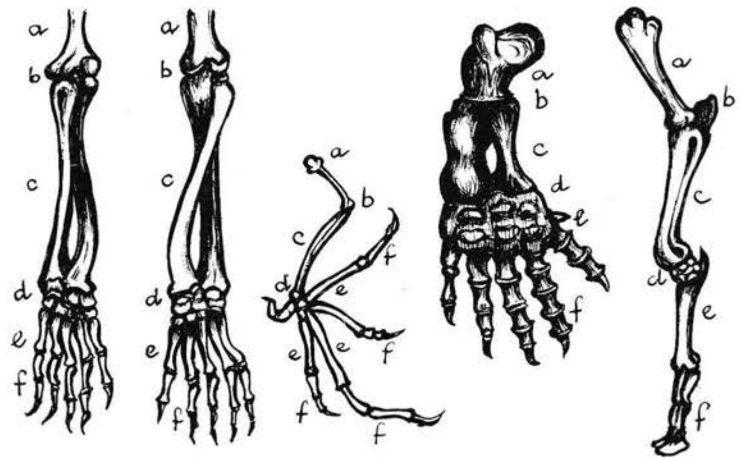


FIG. 12 *Fore-limbs of Mammals*

A. Man B. Gorilla C. Bat D. Whale E. Sheep

a. upper arm – or equivalent
b. elbow
c. lower arm
d. wrist
e. palm of hand
f. fingers

adult is the same length as that of the new born child. The length of the spine is the original length of the human being. To this, during his life, is added the length of his head and the legs. The hand can be used as a kind of measure for the various proportions in Man. For example, the hand is exactly as long as the human head without the jaws. If you turn the hand, horizontally, it is just the measure for the jaw. This interesting law has been found by Professor J. G. Carus; he introduced the hand as a measure for the proportions of the human body and called it a "module." The hand is one third of the spine.

We never find such proportions in the animal organism. For example, if we examine a bat we see that it has extremely long fingers. In a horse everything is more or less concentrated on the development of the long thigh bones. The human skeleton is completely balanced, harmonised.

The animal has the same bones in its skeleton as the human being, but they are not in the same proportions. The animal skeleton is fixed in the front, but indefinite at the back. Above we find the form principle, and below we find the material matter. The vertebrae of animals are indefinite in number. The part of the animal organism which is variable is, at the same time, the part which enables the animal to adapt itself to its specific life conditions. For example, if an animal flutters about, as bats do (they do not fly properly), then it is possible for that animal to extend its skin over the fingers, and with this colossal surplus strength it acquires the possibility of fluttering. Other animals develop other parts in an excessive way.

Rodents develop their front limbs in a special way. They possess an immense adaptability in their tails and extremities. These parts are variable in length, adaptable to their environment. In those times of earth evolution when the bony part of animal organisms was not yet quite solid, the form could adapt itself to the necessities of the surroundings.

The human being preferred to be less adaptable. He withheld his development in this direction, and fixed his limbs, his periphery in the skeleton; but he has reserved for himself adaptability for the spirit. He has withdrawn his faculty of adaptation from the limbs, whereas the mammals have kept it in this realm. Therefore the mammals are true limb-system

FIG. 13 *Squirrel*

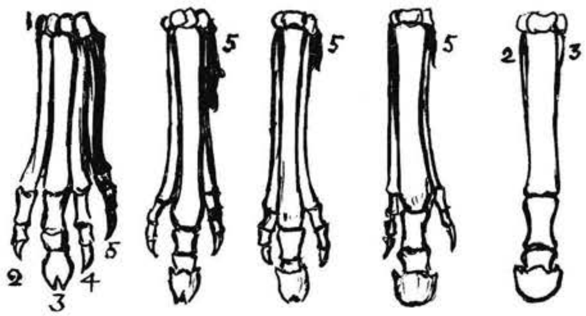


FIG. 14 *Development of Horse's Hoof*

Front feet of 5 predecessors of the modern horse, showing reduction from five toes to one.

A. Hyrocotherium
B. Mesohippus
C. Miohippus
D. Hipparion
E. Equus (Horse)

creatures. The squirrel has wonderful, nimbly-built fore-limbs. They are built for the purpose of holding a nut between them. The nut is already there spiritually, as it were. The beaver has its organism adapted to the faculty of building its wonderful architectural dam. Other mammals are adapted for the function of climbing or running.

In geology, we can follow, to a certain extent, the development of animals. For example, at the beginning of Atlantis, or according to geological terminology, the Tertiary Epoch, we find horses with five toes. Slowly, during the ages, horses have developed with only four, then three, then two toes. Finally, as at present, the horse has only one toe, the hoof. Only one bone is left, still we find the other toes in a rudimentary form. We can see them especially in the horse embryo. There the horse starts with five toes. As the embryo develops it gradually loses one toe after another until it finally acquires the well known hoof.

We must consider that during the evolution of our planet earth, only gradually has the surface hardened and become solid, until it was a sufficiently firm foundation upon which a

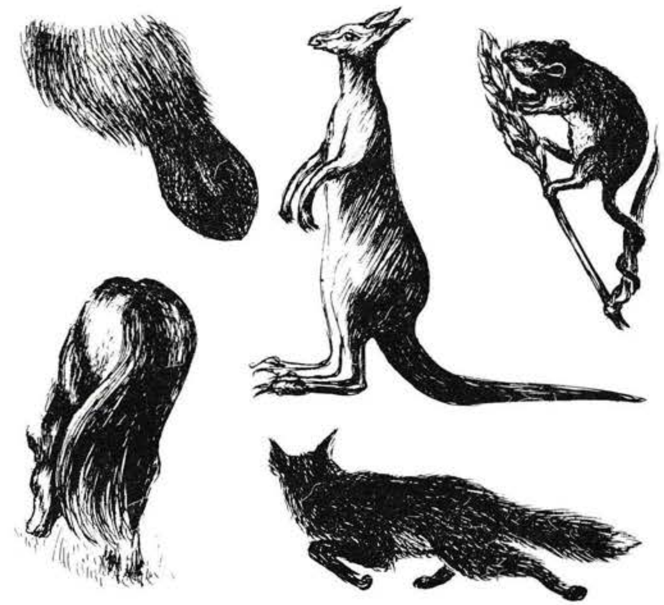


FIG. 15 *Tails with different uses: Female Beaver, Kangaroo, Harvest Mouse, Horse, Fox.*

hoof could tread. Everything in the organism of a horse fits together, from its hardened, but splendidly functioning hoof, to its skull. The four legs are completely skeletonised, transformed into a kind of hard, horny substance. The outstanding characteristics of the horse are: its skull, which is so structured that it needs blinkers, and its extensively hardened limbs. We can study how such a one-sided development arose. As the earth gradually became more and more solid, an animal organism was developing, which became increasingly hardened, until a species with hooves evolved.

At the beginning, the animal forms were not fixed. They did what the earth demanded of them, what the trees demanded, what manifold nature asked of them. They adapted their limbs to the surroundings. Man is very badly adapted to nature. He must replace this lack, by learning. The mammals adapt their extremities to the conditions on earth and become really and truly limb-system animals. From their skeleton they acquire these skilled limbs. In a way, the teeth also can be considered extremities. The versatile limbs and the type of teeth for each species fit into each other like lock and key. What vibrates around the mobile and sensitive finger-organisation of a squirrel corresponds to its incisors. The teeth formation of an animal is a part which is fixed, and this is connected with the continuously mobile limb skeleton. This fact can also be studied in the formation of animal tails. A tail may be rolled, turned, used for climbing, and it may be used as a kind of fifth limb. Monkeys especially have very versatile tails.

Tail-less apes come nearer to Man but do not reach him. Man achieves wonderful proportions in his organism, which the apes can never attain.

In mammals there is a kind of totality, and yet a certain one-sided development, in the adaptability of their extremities to the earthly surroundings. The skeleton is a product of the mode of life. It we look back into previous epochs of evolution, when the bony structure was not yet so hardened as it is today, then living beings could have great changes in their organisms. The scientist Lamarque said, "The requirements create the organism. If a giraffe needs a long neck, then the animal will acquire it." But what about the animals living at the present time? They cannot change as the creatures of long ago could do. This is no longer possible. When studying Lamarque's system, we find that he says: "The requirements create the organisms . . . and heredity preserves them." He is perfectly right, but he is speaking as though he were living in the past. His ideas are as versatile as animals' organisms were in primeval times. His ideas had to be considered "unscientific" because they conflicted with our present-day experience; they do not apply to the present-day animals. The animal organism is now fixed, and the creature is the slave of its limbs. It must do what the inherited skeleton demands. It is restricted by the form of its extremities; the limbs and the teeth. It is instructed by its organs. Man governs and instructs his organs. Animals descended to the planet earth earlier than Man, when their organisms were at an earlier stage of development. Man appeared later and he himself rules and teaches his organism.

It would be possible to show similar phenomena in the senses. Mammals were the first creatures to develop the senses more

fully, but they are always one-sided and unbalanced. The dog has a strong sense of smell, the cat hearing. The predatory animals have a splendid sense of hearing and touch, but their sight is not so good. This group, to a certain extent, does achieve a greater totality in sense perception than most of the other mammals or the birds. But they do not reach the totality of Man; they are unbalanced and one-sided, as far as the development of the senses is concerned.

Man alone achieves totality of the sense perceptions, and he can unite them with spiritual activity. He reaches a more balanced result, in comparison with the mammals.

Mammals acquire their formative forces through the blood, and this determines their structure. They are a product of heredity and adaptability. Not so Man; he adapts himself to nature in a different way. He lifts himself out of external adaptation by learning. He also rises above heredity; although he is bound to it, he overcomes it continuously. To a certain extent he is subject to the laws of heredity, but he constantly conquers them. He is a contrast to the mammals in his conquering of heredity and adaptation, to which the mammals are completely committed. Notwithstanding these facts, the mammals represent a higher development than all the other species of the animal kingdom. Within the organisms of the mammals, is gathered together the whole kingdom of the lower animals, as it were.[1] That is when we look at the mammals from one point of view. Looking at them from a different angle, we may see the mammals grouped around Man, each species expressing a different aspect of the human being. So we have the strange fact that although the mammals are completely different from Man, yet they may be grouped around him. But we must understand this properly, then we will never under-estimate the animals, but also never under-estimate Man.

We look upon those peculiar differences in that world of the MAMMALS grouped around Man; that world which can never be thought of without Man; that world which, in reality, is ONE-SIDED-MAN.

1. See Zoology for Everybody: No. 1. Introductory. The Snailshell and human ear; worms and intestines, etc.

ZOOLOGY IV

VARIOUS TYPES OF MAMMALS

An important fact about the mammals is that these were the first animals to develop a separation between the upper and lower parts of the body. The diaphragm, a muscular, membranous partition, divides the thorax from the abdomen. This produces a separation between the chest organs, that is the heart and lungs, which are concerned with the blood circulation and breathing; and the organs of metabolism, reproduction and excretion: those of the abdomen.

If we consider this division into chest and abdominal organs, we enter a sphere where we find many radical differences between the various species of mammals.

We will now study in greater detail the various types of mammals. They can be divided into two main groups. This is stated as an assertion at the beginning. Later it will be possible to prove it, giving the facts.

Usually we discriminate between many types of mammals. They can really be reduced to two main groups, according to the separation of the body into two parts by the creation of the diaphragm. These two groups are the predatory animals and the ruminants. These represent the main mammals; the rest may be grouped around them.

The predators distinguish themselves by their specific mode of life, and also by the structure of their bodies. We will begin with those parts of the organism which we found characteristic for the various species: the skeleton and the dentition. Predatory animals, such as the tiger, develop the middle or canine teeth most prominently. With these canine teeth they tear their prey to pieces. These animals have only a few molar teeth; the jaw is

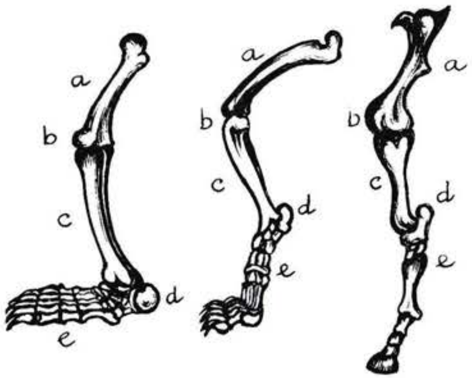


FIG. 16 *Hind-limbs of Mammals*

A. Bear B. Wolf C. Horse

a. thigh
b. knee
c. leg
d. heel
e. foot

short, and the upper teeth overlap the lower ones. It is quite obvious that the formidable canine teeth are the most developed in the tooth formation of the predatory animals. All beasts of prey, such as the lion, the leopard and the cat develop canine teeth strongly.

The limbs of nearly all these animals terminate in claws. They are very lithe creatures, which accounts for the characteristically slinking movements of their bodies. Their limbs are very mobile; many of them are inclined to be bow-legged. The whole body of a cat, a lion or a tiger is supple, and the middle part of the skeleton is extremely well built. In the skull, too, it is the middle which is prominent; the upper and lower parts are comparatively insignificant.

In a lion, as in other animals of the predatory type, the thorax and the ribs, the middle part of the body, is that which is strongly developed in the bony skeleton. Both the limbs and the claws are inclined to be curved. This characteristic is reminiscent of the ribs. It is as though this curved character of

the ribs is continued into the limbs and claws. We could consider the limbs to be transformations of the ribs. An interesting fact is that, in the skeleton, the bones of the arm are just the same length as the rib bones. In the predatory animals, the whole skeleton has more the character of ribs, and this tendency extends right into the formation of the claws. In other types of mammals this tendency has been lost, especially in those animals with straight vertical legs, such as the horse.

If we watch a cat trying to catch its tail, we see how it can roll itself into a complete ball. The cat is built so that it can easily do this, because its body is so supple. A horse could not achieve this! I only want to show how differently all the animals are built. Because of their lithe, supple bodies, the predators can form themselves into a complete circle, a ball.

Furthermore, we find very well developed muscles in beasts of prey, especially in the chest region. The senses of hearing and sight are very alert in these animals. They need these in order to catch their prey.

It is interesting to consider how the whole character and mode of life of these predatory mammals has become associated with certain qualities, which, in Man, we would describe as emotions or soul qualities. We use the phrases: "lion-hearted" or "bold as a lion"; "fierce as a tiger"; "sly as a fox." Comparisons with these animals are used to express qualities in Man fluctuating between courage and cowardice. The hyena is associated with cowardice. The predators attack other animals, devour them, nourish themselves with the blood of their victims; thus they are "bloodthirsty."

The middle part of the body, whatever is connected with the thorax, is especially developed in this group of animals. The characteristics of this middle part penetrate even into the limbs. How insignificant is the back of the animal in comparison! The intestines are not very long in carnivorous beasts. The digestion is rapid, especially as far as albumen is concerned, which is dealt with in the fore-part of the bowels. It is a very intensive process, designed to incorporate nourishment into the blood quickly, and make the animal ready again for fresh food. Not much time is spent on digestion. It is an **in**tensive, not an **ex**tensive digestive process.

The most characteristic animals of this group as have been mentioned are the cat-like species: the tiger, leopard, panther and the cats. One special animal expresses the characteristics particularly clearly: the lion. Its impressive mane, which ends abruptly, covers the head and chest, and gives the specific "lion" character. It does not look like a head, there is no proper forehead, the head as such is not overwhelmingly developed, but it looks so marvellous because the mane envelopes the whole breast. A lion looks so grand and imposing from the front, and so incomplete and insignificant from the back. It is most impressive that a lion looks so majestic in front, and does not "live up to expectations" at the back. He develops the middle part of the organism prominently.

The lion's voice; that deep, roaring sound, comes from the depths of his thorax. The lion's roar deeply affects all other animals; they are terrified of the lion's voice. This is not because they fear what might happen to them. They do not understand, but the roar goes through bone and marrow, because the whole blood organisation of the animal revolts when this thundering roar is heard. If the animal had to "think" about it, as you sometimes find it stated in textbooks, then the effect would not enter so deeply into its organism. The cry of an ostrich is much louder; it is much more noisy than the roar of a lion, yet it does not strike terror into the hearts of the other animals, as does the roar of the lion. There is a clever exposition in one text book about the cause of the incredible impression the lion makes. The author thinks that the other animals know, on hearing the sound, that something is going to happen to them. It is the whole character of the lion's roar, streaming from the depths of his chest, which impresses itself on the other animals.

The lion has immense strength, but it is confined to the moment, and is not maintained for a longer period. Everything in the lion is designed for quick action. The leap is mighty, and the capacity for elasticity in the jump is born from the chest organisation. Not all the parts of an organism are elastic. Where do we find elasticity in Man? In the middle part of his body, the ribs are elastic. The predatory animals have developed this quality still more than human beings. Their sinews are very well formed; these represent the intermediate state between muscle and bone. The sinews take part in the intensity of the jumping

movement. The whole organism of the predators is imbued with elasticity. This is especially apparent in the lion.

The blood circulation of the lion is very quick; this makes it possible for his whole body to be, more or less, an expression of the movement of the blood. The digestion is very rapid too. It is strange how these animals have inscribed into their bodily structure such a longing for a connection with the blood of other animals.

It is also very interesting that the habitat of the lion is limited to localities with certain sun conditions. He is at home in areas where there is intense heat and dryness; in the deserts the lion thrives best. Certain definite countries, with strong sun influences satisfy his requirements. Africa, where there is an immense reflection of sun forces from the earth, offers the lion a climate necessary for his well being. The desert is his real home. He is the most representative of the predatory type of animal.

Around the lion are grouped the other cat-like species, such as the tiger and panther. There is also another species of predatory animals, in character like the wolf; the wolf still hunts its prey. But the predatory characteristics are expressed much less intensively in the dog, which was derived originally from the wolf. Other beasts of prey are like the fox; such animals may be very small, and live in trees and bushes, like the marten and the weasel. All kinds of intermediate forms exist, which lead us slowly away from the predatory types towards another group, the rodents. Beginning with the fox as a type, and passing on to the marten and the weasel, we come to the smaller animals, which become more and more mobile and have the tendency to climb. Of course, this is also expressed in some of the true predators, in their suppleness and elasticity. With their lithe bodies and capacity for leaping, they are not fixed firmly to a life on the solid earth.

We find certain extremes, certain contrasts among the beasts of prey. The hyena is a complete contrast to the lion. The hyena is not so keen on fresh blood, and likes to eat decaying corpses. It is a cowardly beast with a peculiar organism. The body is sloping; the form of the head is also strange. The whole body seems to withdraw, there is discord in its organisation; it is a degenerate lion nature. There are great contrasts in other ways. The tiger is not so generous in its nature as the lion; it is more

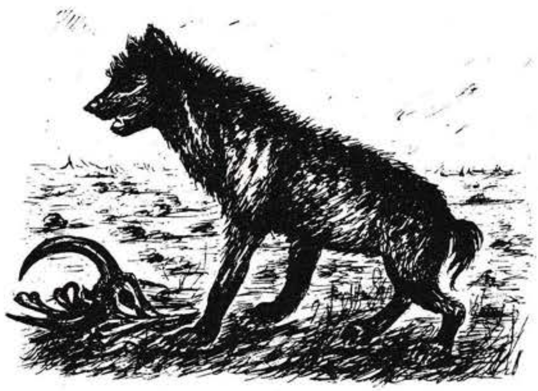


FIG. 17 *African Spotted Hyena*

cruel and bloodthirsty. It would be possible to demonstrate all kinds of variations, leading from the lion to other animals. In the fox a cunning nature appears, leading to smaller, more mobile animals. There are also other types of digression.

The bear is different from other predators. It not only eats meat, but it also likes honey, which seems strange. The bear walks on the soles of its feet, and comes more deeply down upon the earth than most predacious animals. It tries to get into an erect position, standing on the soles of its feet. It is rather clumsy. It is an intermediate form, leading from the predatory animals to those heavy creatures which rest solidly on the earth. Everything about the bear is in an intermediate position. In a way it is grotesque. There is something awkward and clumsy about it; at the same time it is amusing. We always find that there is something comical when an intermediary form is created. It is so with the penguin, which cannot decide between two types of form. Some of the apes, too, are similar in this respect. They are grotesque because they are not fully adapted to their own type. They do not represent a certain idea fully and completely. A cat is not grotesque because, as a cat, it is in itself complete and perfect. A bear is comical because it still unites a cat's nature with some other characteristics which are more coarse and are nearer to the earth.

The bear has a special way of overpowering its prey. It approaches like a fond lover, embraces its victim and, at the

same time, crushes it. The bear easily learns to dance, which again is rather quaint. This shows that it is not quite rightly fitted for the earth. It can neither run nor jump properly, consequently it makes these peculiar intermediate movements. The intestines in the bear are longer than in any other predatory animal. The fact that it walks on the soles of its feet, and that it also develops the intestines, the metabolic system, and the hind legs more fully, shows that it is more solidly down on the earth than other predators.

So we can study the various phenomena which lead us away from the truly predacious mammals, towards those more down on the earth, such as the bear, and those climbing into trees, such as the marten and weasel.

It is a good idea not to cling too rigidly to the stiff classification we find in text books. Some of the animals usually included in the rodents, definitely belong to the predacious group. Examples are the shrew and those animals which feed on insects. These are predatory creatures trespassing somewhat in an upper direction. Even such an animal as the hedgehog shows such characteristics. These animals are smaller than the ones we have already described and they acquire special skills. The hedgehog and the shrew resemble, and come near, to the group of rodents. We see that the Insectivora, the insect eaters, are pre-

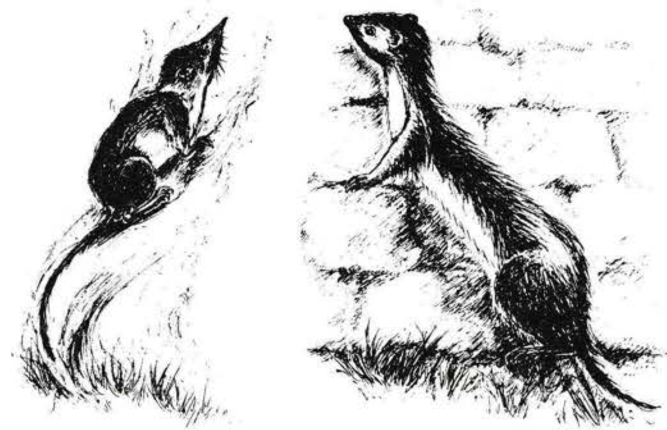


FIG. 18 *Shrew and Weasel*

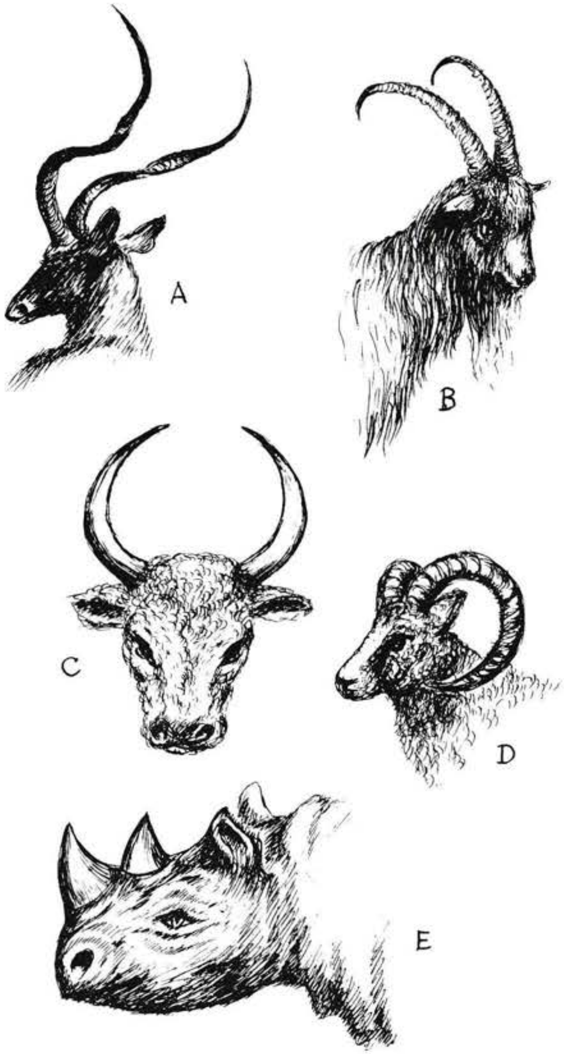


FIG. 20 *Horns*

A. Male Impala (Africa)
B. Male Goat (North European)
C. Chillingham Cow
D. Male Soay Sheep (St. Kilda)
E. Black Rhinoceros

The metabolism is reflected back into the organism, through the horn formation. Animals with horns have a dulled-down sense-activity. Their nervous activity is subdued because the stream of metabolism is reflected back into their inner organism. They produce horns on their heads and hooves on their feet, and thus concentrate the forces of their metabolism into the interior. The horn and the hoof, on the periphery of the body, act as reflectors, directing the metabolism back into the interior. Therefore the cow is not very sensitive to the outside. It is wrong to imagine that an animal is limited within the boundary of the skin. The sensitivity of many animals reaches much further than that of the cow, and other horned animals. Cats, for example, notice through their whiskers when something is happening in their surroundings. Animals show a similar phenomenon to that found in certain *mediums*. If we prick with a needle into the air surrounding a sensitive medium, we produce a sensation of pain in the medium whose sensitivity radiates into the periphery. The body is asleep, but the medium is sensitive in the area around the body, and will cry out in pain, if we move about with a needle. The sphere of sensitivity has been dislocated from the body into the periphery. This phenomenon is more obvious, in certain small animals, than it is in mediums. But we do not find it in the cow; there the sensitivity has withdrawn into the interior, into the metabolism. The cow digests with enormous sensitivity; its whole interest is centred within its organism. With the same intensity, with which other animals occupy themselves in the outside world, the cow devotes itself to its inner life processes. Its whole interest is centred upon its inner organism. The horned animals are unresponsive to occurrences around them, thus strengthening their metabolism.

The bull, once excited, butts with its horns; this only shows a lack of sensitivity. It is irritated by something and uses its horns, exactly that part of its organism which represents a lack of sensitivity. Horns and hooves reflect sensitivity towards the inside. The most beautiful horns are those curved like the crescent moon. This is the innermost tendency of the horn. Its surface is smooth and it is hollow, mounted on a bony cone. It is formed by the metabolic system, and acts as a reflector for this.

The *horned cattle* are prototypes of the ruminants; they concentrate completely on the digestive process. They excel in milk

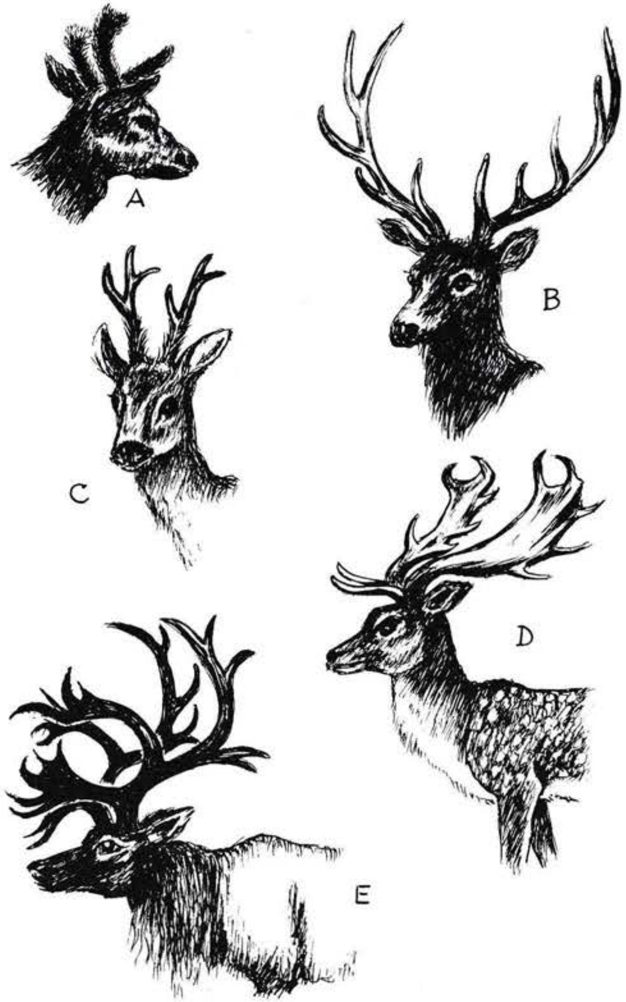


FIG. 21 *Antlers*

A. Red Deer "in velvet"
B. Red Deer
C. Roe Deer
D. Fallow Deer
E. Reindeer

production, which is a metabolic function, and it is not surprising that, in the cow, it has reached a certain perfection. Just as the hen excels in egg production, so does the cow in milk production. The cow is organised especially for the process of converting grass into milk; this is the peculiar chemistry of the cow. Sometimes one feels that this strange process of transformation is not brought about by any animal, but is the direct result of a cosmic force, which prepares this marvellous food in mammals. At the same time, something akin to a vegetative process enters into the organism of a cow. The production of milk is the most important function of this animal; it is not nearly so important in the predacious mammals. This is closely connected with the cow's insensibility to the periphery, as is its horn and hoof formation and all the other qualities characterised.

We notice that the cow does not produce fur or bristles. It is not customary to ask, "Why has a cow no fur? Why has it no bristles?" The most ruminants can manage is to make wool, which is strongly permeated with fat. Predatory animals do not produce wool; only ruminants do so.

Ruminants with antlers, such as the chamois, the deer, the antelopes are very different. Although they are ruminants, they are very sensitive. We cannot compare a horn with an antler. In the latter there is a strong radiating force. The more beautifully formed an antler is, the more strange the impression it makes upon us; something radiates from the animal. The antler looks plantlike, in form it resembles the branching of a tree. These animals, which usually live in forests, seem to have a forest growing on their heads. They are shy, very swift in their movements, and extremely sensitive. In earlier times, not so very long ago, people had a distinct feeling for the peculiar nature of these animals. There are pictures, by several artists, of a stag with a halo surrounding its head; it is called St. Hubert's stag. Then, in earlier times, people could perceive that these animals radiate something into their surroundings, there is an immense sensitivity around the head of a stag. They are very timid animals and are easily frightened. If we look into the eye of a roe, we see that it expresses a whole world of fear. A frightened roe utters a cry which is an expression of the utmost fear.

The legs of these animals are very thin, fragile and mobile. They are exactly opposite to the horned animals, in which nervous activity is blunted. Horned animals stand solidly on the ground. The animals with antlers are very delicately built. Yet they develop enormous antlers which seem to hover above their heads. The antlers are light, and are easily cast off. This is an astonishing phenomenon, that this huge growth is produced on the head, and yet it can be disposed of so easily. During the period of its growth, the antler is well supplied with blood; it is then full of life and enormously sensitive. We feel that much is happening in antlers, but that nothing happens in horns. Whereas the horn is a dead organ, reflecting everything back, the antlers are cast off and formed again. This is connected with the process of reproduction.

The animals with antlers are not confined within their bodily organism, they are sensitive and "scent" far out into the distance. The extent of their range of action is large. This is apparent in their eyes and in their sense of smell. In spite of being ruminants, these creatures develop their nerves and senses system.

We find the most varied types among the ruminants. The camel can form neither proper horns nor antlers. It can deposit fat in its body, and can then do all kinds of things with this deposit. It can eat the fat and then produce it again. This is connected with its peculiar metabolism, which is adapted to life in lands of great warmth and dryness. Camels can live in deserts for an indefinite period of time. They can nourish themselves with their own fat, deposited in the organism. They can also manage without water for a long time. They seem to have a very frugal existence, from the outside point of view. But, within their organisms, peculiarly vivid processes take place. What happens in connection with the forces which develop horns or antlers in some ruminants, takes another form in camels. They acquire the ability to deposit materials in the periphery of their bodies.

Thus we find strange and contradictory processes in the various representatives of the ruminants. Again we can trace an interesting sequence of intermediary forms from the horn to the antler. At one end we have the horn, the curved structure; at the other the antler. The horn is smooth; the antlers are rough and porous. The one is a really animalic organ, connected with the

interior of the body; the other is more plantlike and mineralised, fits only loosely, and is easily cast off. It is like an independent tree formation; whereas the horn fits closely to the head and serves the metabolism. The antlers serve as an extension of the animal into the periphery. If we take a further step from the true ruminants, we find quite a wide circle of animals linked with each other. The horse is an example of one type, in which the leg is terminated by a single hoof. The horse does not ruminate, that is, chew the cud. It has a different formation of the teeth from the real ruminants. We find incisors and molars, with a gap between them. The horse belongs to the quadrupeds living on land, but it has developed the limb system more and the metabolic system less. It has straight, stiff legs, hardened towards the hoof. It certainly fits into the whole group, even if it has not the capacity to ruminate.

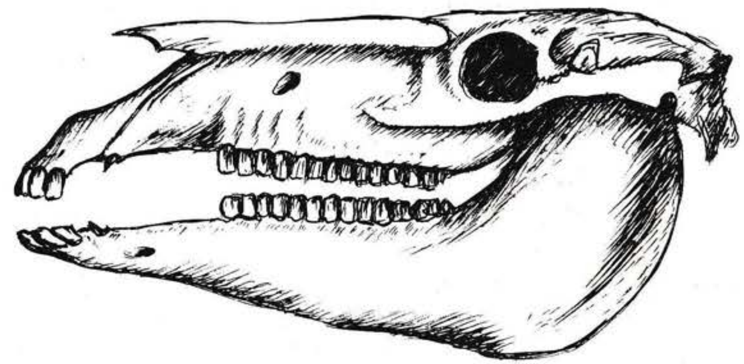


FIG. 22 *Skull of Horse (showing dentition)*

Then there is a group of animals like the pig. It has molars, incisors and canine teeth, and eats everything, all types of food. This type, like the pigs, stand in a somewhat middle position. The characteristics of the wild boar are reminiscent of the predacious animals, whilst in the domestic pig the contrasts between predators and ruminants are partly effaced. The pig is undifferentiated. Well fed pigs have the tendency to form a ball, to become quite round. Their physiognomy is somewhat deformed. The whole animal gives the impression of well-being, but seems to have complete indifference towards the whole of the outside world. It can stand everything; its blood cannot be poisoned; pigs cannot get blood-poisoning. It is possible to operate on pigs without taking special precautions, whereas one has to be very careful with horses; more careful than with Man; a horse is very sensitive. A pig has a very robust organism and can digest anything, without damaging the metabolic system. Its vitality is so great that it can bear all this. This animal combines everything synthetically, which enables it to digest anything. It can easily be fattened, forced from outside, to do what is already its inner tendency, to grow fat. A little piglet delights us with its rosy appearance; the blood shines through the skin. Its snout also shows how the blood penetrates to the surface. In older pigs the rosy colour is not so obvious.

Pigs are especially vulnerable to certain diseases, such as erysipelas (red murrain). This disease is only an exaggeration of what is always prevalent in a pig, the tendency of the blood to stream into the periphery. It seems that the force which causes coagulation of the blood is not very active in the pig. The albumen is very robust, but the pig is lacking in formative forces. The two fundamental types of quadrupeds, the ruminants and the predators, do not come to full expression in the organism of the pig. It is as though the pig organism is built independently of the specific qualities otherwise predominant in animals. We must place the pigs in a middle position between the horned and antlered types of ruminants and the predators.

The rodents can be sub-divided into different groups. Some have the character of predacious animals, others have qualities showing a tendency towards the ruminants in type. The squirrel, and a still smaller animal, the shrew, climb trees. They tend to show more similarity with the predatory types, only they are more nervous than the beasts of prey. Others, like the rabbits and their larger relatives resemble more the ruminant kind of mammal. Some hares, the more exotic species, are close to the earth, while others are more mobile. If we classify the rodents properly, we can always relate them either to the ruminants or to the predators. Their skeletons are very mobile. Goethe drew attention to this fact. It is the fore-limbs which show this quality of mobility especially. The squirrel can turn its hand round. The rodents have a tendency to free the fore-limbs, to sit upright, to make gestures which bring the fore-arms up to the mouth, and to use them in conjunction with the teeth. Rodents develop the incisors, the "nervous" teeth especially. This gives them problems; they must use these teeth constantly, otherwise the incisors, continuing to grow, become too long and the animal runs the risk of either choking or starving. The jaws of rodents can become closed, clamped together, because the incisor teeth have grown too long. The rodent must gnaw and nibble, to prevent excess growth of its front teeth; it is the slave of its incisors. Its peculiar nibbling activity is explained by this necessity. Rodents do not only eat; they destroy, by gnawing and nibbling constantly. If we can imagine this tendency to be guided properly, then instead of being destructive, it gives rise to artistic skill. The beaver building its dam is an example of this, whereas the mouse only moves material about aimlessly, in a process of destruction.

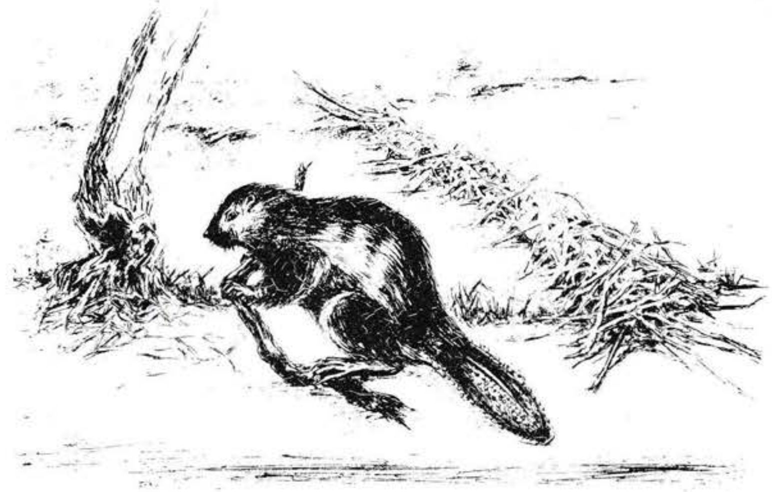


FIG. 23 *Beaver and dam*

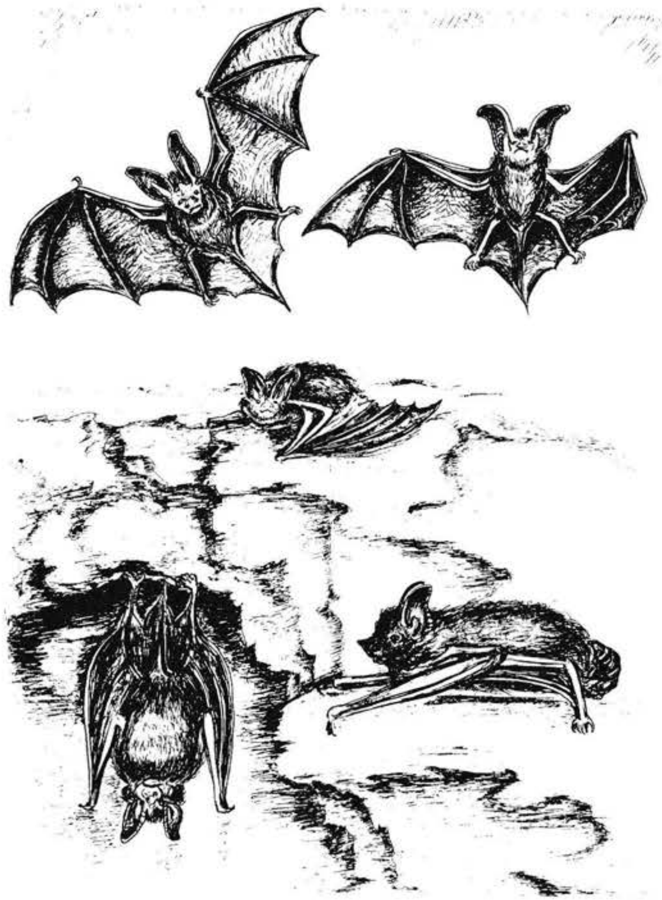


FIG. 24 *Bats*

Rodents are the smallest of the mammals. We can trace degrees of development among them, showing how they become more and more nervous as they strive slowly towards the acquiring of a head organisation. They do not reach it and so become restless. They strive towards something; they climb trees; they would like to fly in the air. Finally we find an animal like the bat, a mammal, which, in a peculiar way, begins to live in the air. The bat cannot really fly, but flutters; it is the flitter-mouse. The bats do not possess proper wings, but webs made of skin. These

are stretched over their fingers, which are elongated. This produces the enormous sensitivity of touch which bats possess; it is this sense which they use when moving about in their surroundings. Bats are uncanny creatures. They strive to become birds, but do not achieve their aim, and become degenerate. Thus there is something negative and eerie about them. They live in twilight and dwell in places which are falling into decay. We find them in ruins, where the atmosphere is weird. They sense this, and like to live in such surroundings. Their range of activity is small, but they would like to become birds. Their bodies shrink and look burnt out; there seems to be a sort of mummification process expressed in their organisms, and yet there is great sensibility, too. These animals are closely related to the rodents.

Rodents are partly predacious in character, partly like ruminants. In this group we feel that there is a striving after the bird type, a struggle to enter the element of air. The birds have developed the beak formation. The rodents develop the incisor teeth prominently, and also a well-developed nerves and senses system. If the rodents progressed towards a hornification process, they would arrive at beak formations. This mammal type does not quite achieve the bird organisation but strives towards it.

Bats cannot fly. They must first climb up and then they can glide down. It is not real flying, only a kind of fluttering glide. They do not achieve the bird-like characteristics. There are only the two types among the rodents, the predacious and the ruminant. Mice have acquired voices; they squeak and whistle. In their climbing and jumping movements they imitate the activity of the birds slightly, but they do not achieve their aim. They only become destructive parasites. Goethe says that, in trying to attain the qualities of birds and not reaching them, the various forms of the rodents appear.

There are other groups of mammals. The variety among them is due to the fact that the development of the mammals ceased in various steps. Thus there are fish-like mammals which remained behind in the water, like the seals, the sea-lion and the walrus. True mammals belong to the element of earth. The seal is the most intelligent and mobile of this group. The walrus is dull in

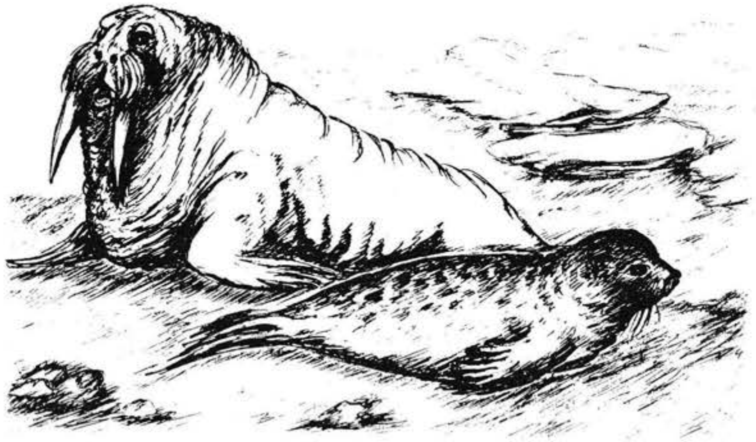


FIG. 25 *Walrus and Common Seal*

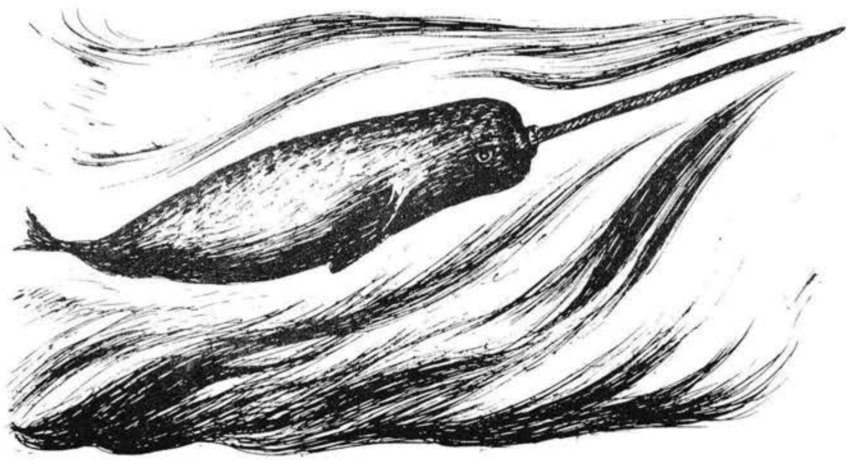


FIG. 26 *Narwhal*

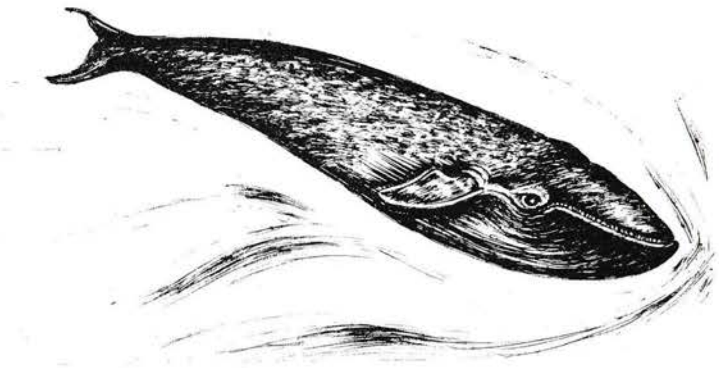


FIG. 27 *Blue Whale*

comparison with the seal; the sea-lion and the walrus develop the lower part of the organism more fully than the seal.

Then there are whales, porpoises and dolphins. The narwhal is close to the predacious mammals; the whale is nearer the cow type; it does nothing but open its enormous mouth and allow sea-water, with its contents, to flow through it. It deposits an enormous amount of fat to keep its blood warm; it has an armour of fat. It has no teeth, but barbs which form a kind of sieve to trap fish. The whale is entirely passive, an enormous mass of floating fat; it has a phlegmatic temperament. This is a type of mammal which has acquired the character of a fish. In our time, whales are dying out.

Other mammals are the remaining representatives of animals prevalent in previous epoches of evolution. The Pachyderms are creatures of very ancient times. The mammoth has already become extinct, and the elephants are the last remaining representatives of this ancient, wise, head-type. Others, such as the hippopotamus and the rhinoceros represent mammals of earlier times which developed the metabolic rather than the head-system. They are similar to the cow; they even show a kind of horn formation. These are huge, coarse, uncouth animals.

The tapirs are the primeval form of pigs; these very first mammals of the Tertiary Epoch unite in themselves all the various types. It is not easy to decide whether they are predators

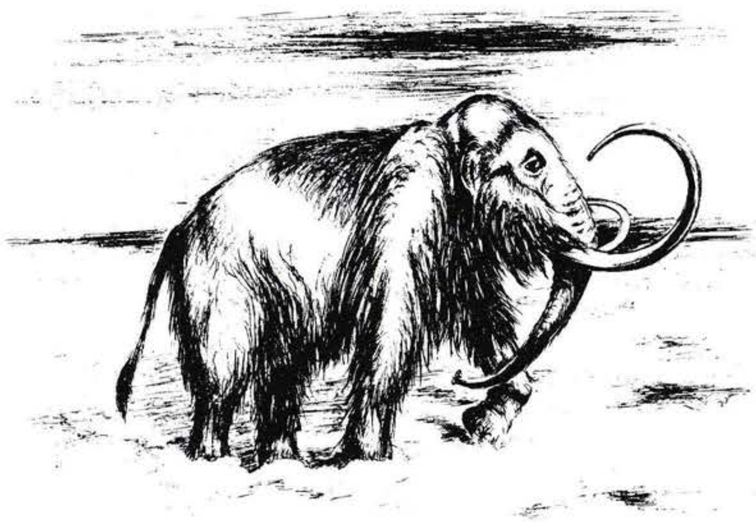


FIG. 28 *Mammoth*

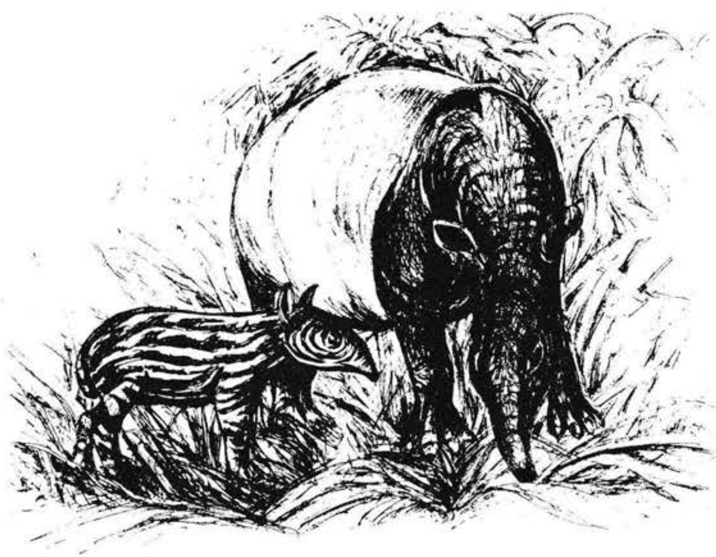


FIG. 29 *Tapir and young*

or any of the other types. The Pachyderms, the remains of previous epochs, do not really fit into any group.

We have already considered the Australian fauna of pouch-bearing animals, the Marsupials, and the Duck-billed Platypus. They represent a quite special animal world. Australia split off from the other continents early in evolution, and so the mammals could not develop there.

So, in reality, we return to the two fundamental types: the predators and the ruminants. There is only one group left over: the monkeys. They can only be understood if we look at them from a different standpoint. They have the tendency to combine all the various types in a way similar to Man. Just as the rodents do not reach the birds, so the apes do not reach Man. In striving to attain to Man, and not achieving the goal, the grotesque form of the ape is created. It is true that the tail-less apes have a semicircular, evenly arranged tooth formation, containing all the various types of teeth, canines, incisors and molars.

A peculiar line of development begins in the apes. The arms have the tendency to become shorter, and the legs to become longer. Neither can be achieved fully, and so it happens that the disproportion becomes more apparent. The heaviness of the limbs is very obvious. We find all kinds of apes, some more like the predatory animals, some more resembling rodents, some tail-less apes which are more similar to Man. Apes have a tendency to become upright, but they do not attain this completely either. The apes are organised differently from all the other animals because they want to unite all the various types of mammals, including Man, but they cannot accomplish this. The apes attempt to achieve a kind of harmony, but it remains in the sub-human stage. So we must place the apes in a special group.

Just as the parrots are between the types of birds, so the apes are between the different kinds of mammals. They try to unite the two fundamental groups of mammals, the predators and the ruminants, and they would also like to include the qualities of the birds.

In Man the bird character is present, but in a spiritualised form; it is transformed into the thinking capacity. The bird organisation is not obvious in Man physically. It is contained in the activity of the head and the arms in the human being; in capacities and activities, rather than in the physical. Whereas in

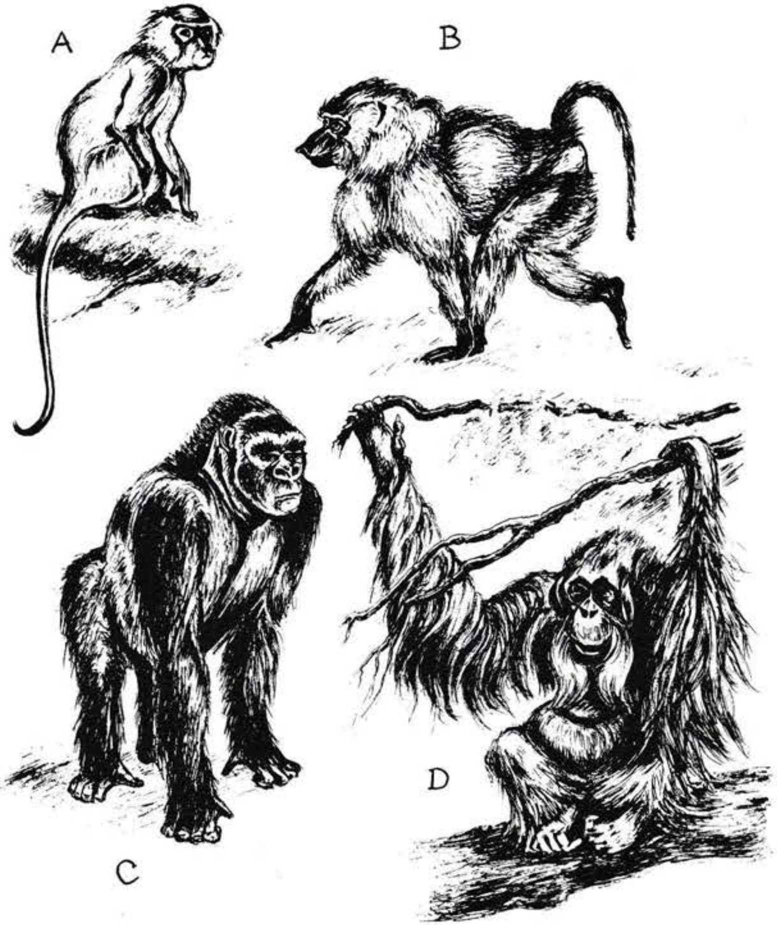


FIG. 30 *Apes*

A. Long-tailed green Monkey
B. Baboon
C. Gorilla
D. Orang-utan

Man the predatory and the ruminant mammals are reflected physically in the thorax and the abdominal organs, the head is independent and does not betray that something of a bird nature is hidden within its forces. The ape tries to unite these three types but does not succeed in producing a likeness to Man. So the apes stand as a particular type in the animal kingdom.

The mammals can be traced back to the two fundamental types: predacious animals and ruminants. It would be good to abstain from observing only those types which are usually put together. Instead we should watch more intimately how the two fundamental groups mentioned here struggle and strive in the formation of the mammals. Only the apes trespass beyond this duality; the rodents do not.

So we have tried once more, as we have studied single animals, to understand the connection of Man with the mammals, at the same time trying to see and understand the contrast.

Now, to a certain extent, we have concluded the study of the mammals and birds. In the next lecture we will proceed to study the lower animals. We will start from the bottom, studying the history of the evolution of the lower animal world. It was not possible to study the higher animal kingdom in this way. There we must look at Man, and group the animals around the human being. Now we will start from below and proceed towards the higher animals.

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THE AUTHOR

EUGEN KOLISKO, one of Rudolf Steiner's most distinguished pupils, was educated at Vienna University as a doctor of medicine. He was also an authority on the Natural Sciences and History, and was a born teacher. As a lecturer in medicine, zoology, chemistry and history, he was much in demand, both in Europe and America. He died in London in 1939, at the age of 46.

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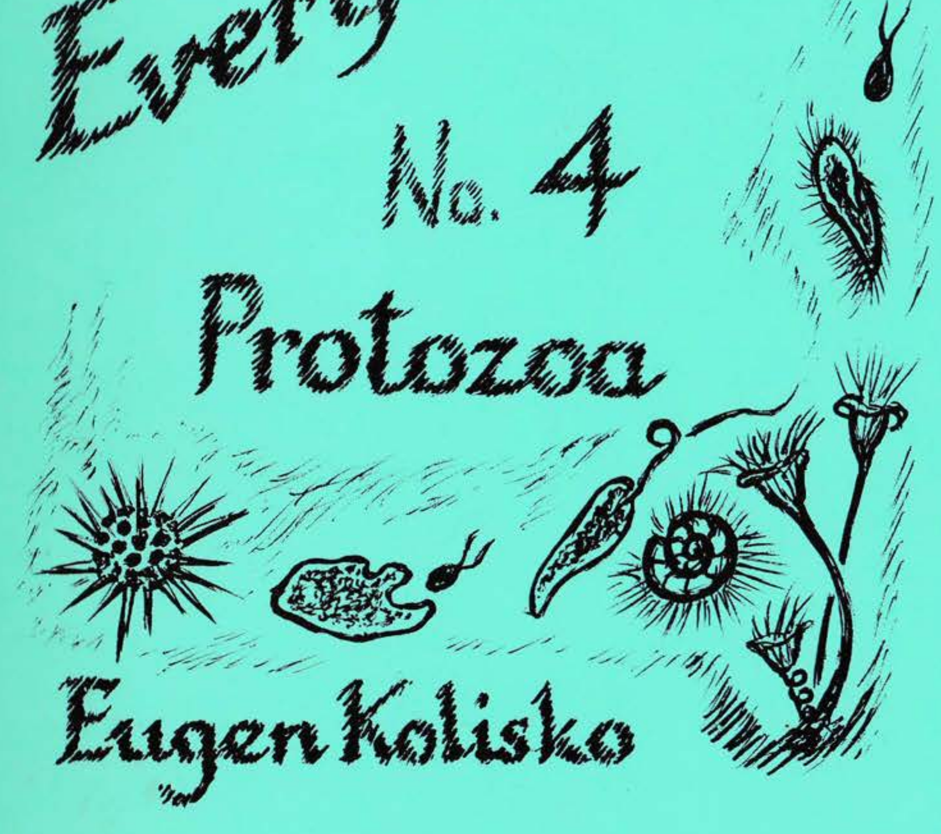
Zoology for Everybody

No. 4

Protozoa



Eugen Kolisko

ZOOLOGY FOR EVERYBODY

A Series of Lectures

by
Eugen Kolisko
(M.D. Vienna)

5th Lecture
Protozoa

Kolisko Archive Publications
Bournemouth, England.

Translated from an original German manuscript by Susan Stern and G.A.M.Knapp.

Illustrations by G.A.M.Knapp.

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Introductory Note

Dr. Kolisko intended to write a book on Zoology, incorporating the material contained in his series of lectures given in 1932. This was not accomplished in his brief life.

Soon after his death, Mrs. L. Kolisko published the first two lectures. In 1944 she suggested sketches which might illustrate Lectures 3 and 4, on the Mammals, which we published in 1979.

In this booklet Lecture 5 on the Protozoa is presented and grateful thanks are extended to Gladys Knapp for her invaluable help and advice in its preparation.

A. Clunies-Ross. Bournemouth, January 1980.

List of Illustrations

ZOOLOGY FOR EVERYBODY
LECTURE V

THE PROTOZOA

Now we will consider the lower animals, beginning with those tiny creatures called Protozoa. These primeval animals are a complete contrast to the higher animals we have studied so far.

The Protozoa are so small that, almost without exception, they are imperceptible to the naked eye. It is only since the invention of the microscope that these tiny creatures have been studied. Before, they were not known to exist. They are present wherever there is water: in seas, lakes, ditches and puddles, especially where there is any decaying matter. They are sometimes called Infusiora. There are thousands of different kinds, of the most varied forms, all unicellular. It is sometimes difficult to say whether they are more animal-like or plant-like; often characteristics of both plant and animal nature are present in the same individual.

Long and intense research, from the seventeenth century, onwards, until the present time, has been necessary, in order to establish facts about this world of the Protozoa, or Infusiora, and to discover the infinite manifoldness of the forms within it. Only be extending our senses artificially, with the aid of the microscope, can this extraordinary richness of form in miniature become accessible to us. What are these different forms in a world so completely withdrawn from our perception?

We will begin with some basic examples. If a little dried hay or grass is left in water for a few days, it will soon begin to decay. A drop of the water then placed under the microscope will probably contain many different living creatures, such as a **Paramecium,** or Slipper Animalcule. This is one of the Protozoa such as Leewenhoek and other Dutch researchers found. This world, of thousands of miniature beings, caused the very greatest astonishment when it was first discovered.

Paramecium, which can be found frequently, is only a tiny fraction of one millimetre in length. It moves rapidly, and almost continuously, with the aid of its covering of delicate hairs, called cilia. Being practically transparent and very mobile, it is imperceptible to the naked eye.

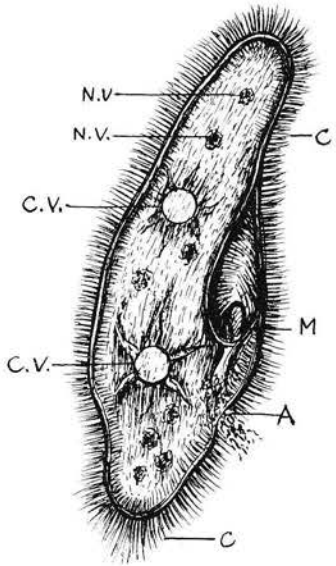

Fig. 10. Paramecium Slipper Animalcule
(natural size 0.20 millimetres)

N.V. Nutrition Vacuole M Mouth
C.V. Contractile Vacuole A Anus
C Cilia

Another of these unicellular creatures is the Bell Animalcule or **Vorticella.** This tiny Ciliate has a sort of "handle" with which it can attach itself to surfaces. This handle can be retracted or expanded. A vortex in the bell-shape acts as a kind of mouth, into which many varieties of microscopical particles of food are drawn. These are soon devoured by the Vorticella.

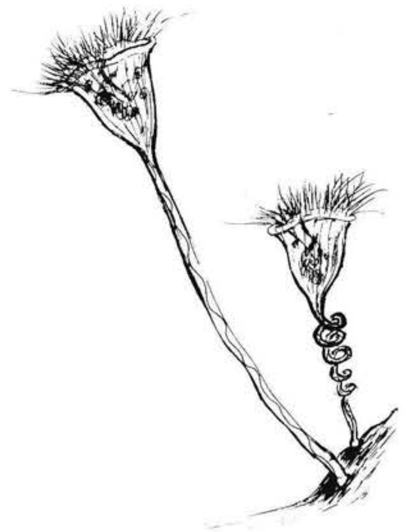

Fig. 2. Bell Animalcule Vorticella nebuliferae
Natural size 0.5 to 1 millimetre
Found in dirty water.

Then there is the **Amoeba,** which is also frequently found in impure water. It is quite different in appearance from both Paramecium and Vorticella. Sometimes Amoeba are found as parasites within other living beings during times of illness. Like the Paramecium, the Amoeba is of one cell only. It consists of a little lump of slimy substance, jelly-like in texture. It is simple in shape. This basic substance is protoplasm, a protein-like material. This is the archetypal substance of life itself.

If we observe Paramecium closely we can distinguish a certain amount of differentiation within it. There is a kind of mouth and a kind of stomach, if we may call it so. There is a sort of interior, where digestion takes place. There are bubbles which expand and contract, whereby a primitive circulation of sap takes place, according to quite definite laws. The expansions and contractions are reminiscent of a heart. If we try to look for something in these tiny creatures which reminds us of the higher animals, we are amazed to find suggestions of the most varied organs: a mouth, a stomach and a heart. These are imperfect images of the organs, but they are organised similarly to those parts of the more highly developed animals. The delicate hairs or cilia, which enable the Paramecium to move, may be compared to the limbs of the higher animals. We are given the impression that in the Protozoa, in simple form, we discover what can be found in the higher animals.

The invention of the microscope, and the research into the world of miniature creatures which it revealed, came before an important principle had been realised. This significant fact, until that time unknown, was that, fundamentally, all the higher organisms show, in their structure, cells like those of which the Protozoa consist. The bodies of Man and of the higher animals are composed of such cells. Everywhere, in the various higher organisms, there are cells which remind us of one or another of the Protozoa. This had never been considered possible, until research began after the invention of the microscope.

The tiny Protozoa beings show a remarkable degree of perfection, especially those which may be found in a drop of water. Whenever water becomes slightly impure, it is soon teeming with innumerable unicellular creatures which are imperceptible to the human eye, unless a microscope is available. This is the world of the water-drop, which is present everywhere in Nature. Millions and millions of unicellular creatures penetrate water and also the organisms of all sorts of animals.

The Amoeba may be considered the basic type of the Protozoa. It is relatively simple in form. It can also change its form. This little lump of slime stretches out a portion of its substance, and forms, as it were, limbs. These apparent limbs, called pseudo-podia, grasp and then engulf any small objects which are potential food for the Amoeba. The tiny unicellular animalcules, or plants (Algae), are

drawn in and soon the victim is digested and absorbed. Thus the Amoeba moves with its pseudo-podia, which also act as a mouth for it.

If light falls on the Amoeba it either draws towards the light or away from it. The pseudo-podia are sensitive, they "grope". It is difficult to say just what they do; it is a process of touching, but also of eating. All the senses flow together, as it were, into the sense of touch. The Amoeba has a kind of light sense, a chemical sensation, and a kind of taste sense, all flowing together into a general feeling. It is also apparent that there is some sort of circulation process. Fluids within the Amoeba are continually flowing from the inside towards the outside and back again; as indeed they do in Man. The arteries tend to have an inward flow, while in the venous system the direction is outward in Man.

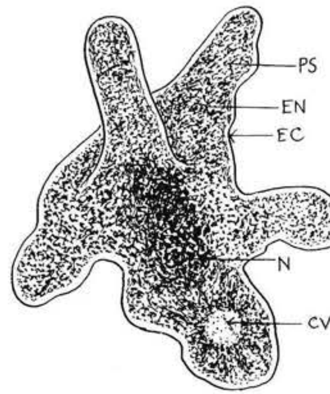

Fig. 3. Amoeba proteus *(highly magnified)*
PS Pseudopodium
EN Endoplasm
EC Ectoplasm
N Nucleus
CV Contractile Vacuole

Something obvious is clearly seen in the centre of the Amoeba. This is the nucleus, which has a very special role; it is responsible for the propagation of the Amoeba. The protoplasm of the main bulk of the Amoeba is colourless and slimy in texture; the nucleus is of similar substance of a denser consistency. The characteristics which are common to all these primeval, unicellular animalcules are:- protoplasm, which is the living element; a nucleus; and a kind of outer skin. If a creature is hurt or mutilated the part containing the nucleus can heal or reproduce the damaged part. The nucleus always moves towards the place where something is happening: to the area of injury or to where food absorption is taking place. The protoplasm of the nucleus is a living fluid penetrated by albumen; it is the primeval substance which is the basis of all that is living. The nucleus is essentially involved in food absorption, healing and in reproduction of the individual.

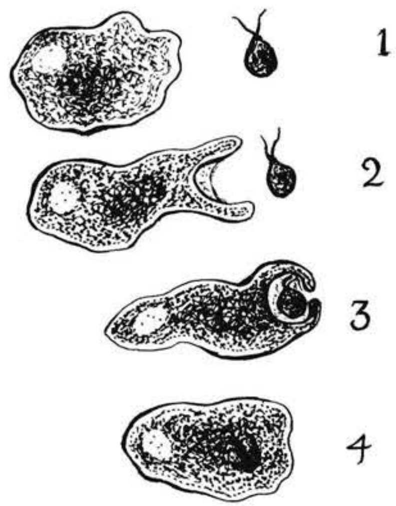

Fig. 4. An Amoeba proteus
Four stages in the process of taking a meal, a small flagellate algae in this case.

The Amoeba is called Amoeba proteus because of its ability to change its shape, to metamorphose. It can take on any kind of form. Its shape is never fixed. Each part can function as limb or mouth, as the need arises. The Amoeba also has a kind of heart because it pulsates rhythmically. When studying the Amoeba, we find that very complicated processes are taking place all the time, although it is apparently a simple creature. It is also astonishing that so much is happening in such a minimum amount of space.

The basic form of the Amoeba can deviate in many ways. The Amoeba reacts to temperature. If the microscope is warmed the Amoeba begins to move, to extend pseudo-podia. If the surroundings are cooled, the creature becomes still and stiff. The Amoeba is very dependent upon conditions in the outer world.

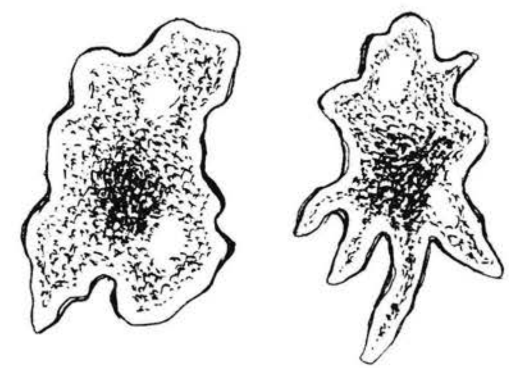

Fig. 5. Amoeba
Two forms of the same Amoeba at two different moments.

The Amoeba devours every possible kind of living being, both animal and plant. We can scarcely distinguish between the Amoeba and the food it engulfs and if we observe later we see that everything of the erstwhile food has been dissolved and has disappeared.

We can observe how the Amoeba reproduces itself. It divides into two, – each half leading an independent life. Division again takes place when the two separate individuals have grown sufficiently large. These divisions, as well as all other processes, are under the control of the nucleus. The nucleus divides in a very complicated process whenever reproduction takes place. After a while, where one Amoeba was before, there are **two** individuals.

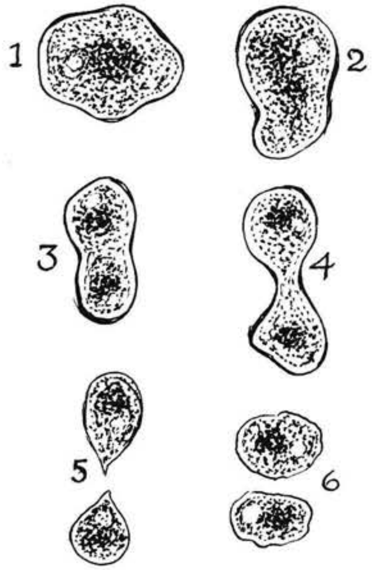

Fig. 6. Amoeba proteus
Six stages in reproduction

There are other types of unicellular creatures more complicated in their form than the Amoeba. Some move much more rapidly through fluids than the Amoeba does. The Paramecium is clothed with tiny protoplasmic cilia, by means of which it can move very quickly.

It is not only in streams, puddles and other water in outer Nature that an "infusion" of the Protozoa or "Infusiora" are found. They are present in the bodily fluids of the higher animals and of Man. There are millions of unicellular living beings in human blood, just as there are millions everywhere in Nature where water is present.

Two other types of Protozoa, besides those mentioned so far, play a significant role in Nature. These are the Radiolaria which have a shell of silica, and the Foraminiferae which have a shell of chalk. Haeckel has described these especially, in his studies of art forms in Nature. There are many different types in both groups, but basically Radiolaria and Foraminiferae individuals are spherical in shape, with an internal form like the Amoeba. But instead of the soft skin of

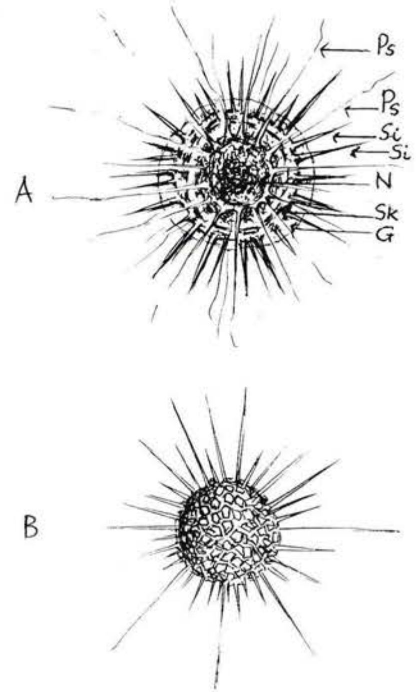

Fig. 7
A. Diagram of Actinomorphyrys sol *(Transverse Section)*
Ps – Psuedo podia Sk – Skeleton
Si – Silica spike of skeleton G – Gelatinous covering
N – Nucleus
B. Skeleton of Actinomorphyrys sol

the Amoeba there is a hard covering. In the case of the Radiolaria this is usually formed of silica. The silica casing has holes or pores through which protoplasmic cilia project. There are also spicules of silica substance. This hard covering is spherical in shape, with projecting spikes, and forms a skeleton, as it were, enclosing the soft protoplasmic amoeba-like centre. Holes in the spherical silica skeleton enable food to be wafted in to the amoeba-like centre. The skeleton is usually covered with a horny substance, through which both the cilia (of soft protoplasm) and the hard spikes of silica project.

When these tiny creatures die, the silica "skeletons" sink to the ocean-beds. The Radiolaria usually live in salt water. Where the Pacific Ocean is more than four thousand metres deep, the skeletons of the Radiolaria accumulate as "oozes", covering the ocean bed. Where the water is not so deep, as in the Atlantic Ocean, the Globigerinan mud covers the floor of the sea. This is of chalk, from the remains of the Foraminiferae, and is found at depths of less than four thousand metres.

Both the Radiolaria and the Foraminiferae play a very important part in the structure of the earth substance. Vast numbers of the shells of these tiny creatures, which we must remember are minute in size, have dropped down on to the floors of the oceans of the world, throughout long periods of time. So very deep layers of mud have accumulated. The reddish mud forming the "ocean-ooze" of the Pacific Ocean consists very largely of the remains of Radiolaria. In places, earth movements have brought the compressed ocean mud to the surface. So some mountain ranges contain rocks which have been formed from the silica skeletons of the Radiolaria.

It does not surprise us that the same thing has happened with the Foraminiferae. The mud at the bottom of the Atlantic Ocean consists almost entirely of the remains of uni-cellular chalk-animals. The compressed mud may be seen as in the chalk cliffs of Dover at the present time.

The chalk shells of the Foraminiferae are full of tiny holes, like pores, through which the animal originally drew in food from its surroundings. The forms of the Foraminiferae are very beautiful and there is great variety among them. Some shapes remind us of miniature snail shells or cuttlefish. Originally the chalk animal remains were thought to have been snail shells, until it was discovered that they belonged to archetypal animals, similar to the

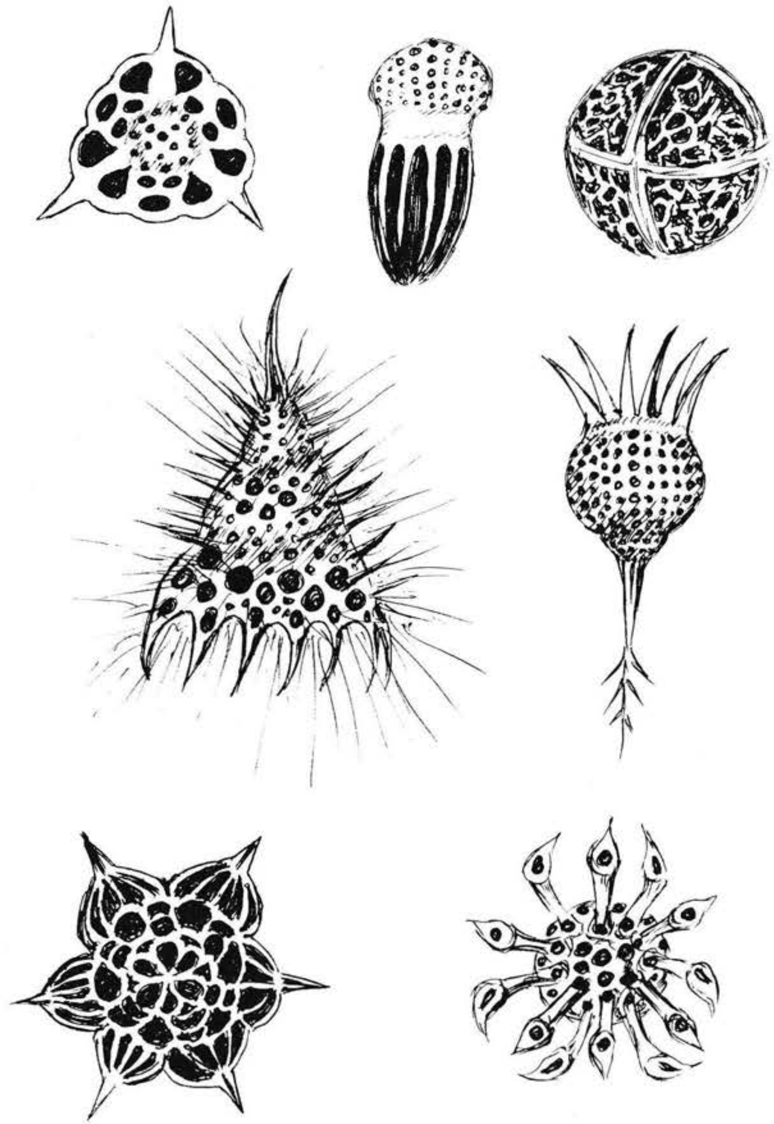

Fig. 8. Radiolaria
Six different Radiolaria skeletons from Pacific Ocean. Living animal of Calocyclus monumentum (with psuedo-podia). All highly magnified.

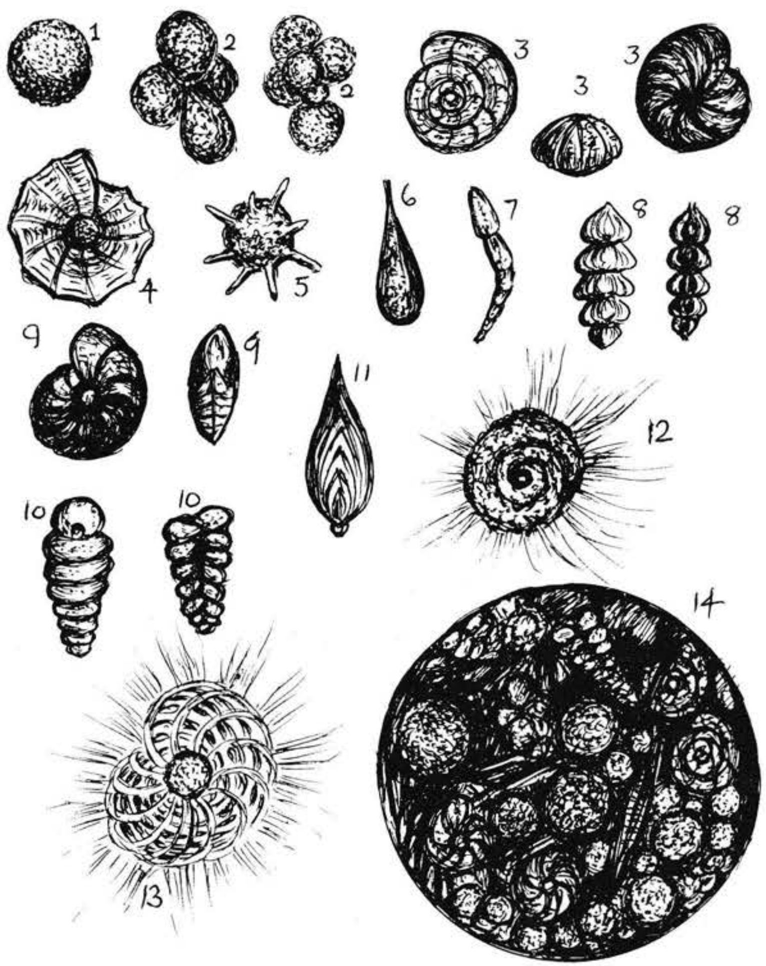

Fig. 9. Foraminiferae *(highly magnified)*
No 1–11 remains of protozoa, 12 and 13 Living protozoa.

1. Orbulina; 2. Globigerina; 3. Rotalia; 4. Polystomella; 5. Calcarina; 6. Lagena; 7. Demalina; 8. Nodosaria; 9. Cristellaria; 10. Textularia; 11. Frondicularia; 12. Spirillina; 13. Elphidium; 14. Globigerina ooze.

Amoeba, but with a shell. Chalk is evidently of organic origin; it has been formed from animalic remains. It is certainly not derived from mineral sources, but is formed from the remains of unicellular animals, which have been compressed into solid rock. Often flints, which are of silica, are found embedded in chalk rock. Later on we will see how limestone is also formed from animal remains of various types. We can see how chalk is exclusively organic in origin, and how the mineral world has been derived from the remains of living creatures. This fact was well known in earlier times. It was stated that "Omnis calx e vermibus"; that is "All lime comes from worms."

Silica, on the other hand, always produces wonderful, geometrical, radiating forms. It is always connected with shapes found in the plant or mineral world. Quartz, with its beautiful six-sided prisms, is of silica. So are the Radiolaria, with their radiating forms. The Foraminiferae, however, seldom produce starry, radiating shapes, but more animal-like forms. What lies within chalk is connected with animal life; what is within silica is found in minerals and plants.

You will have realised from the specimens and pictures you have seen, that the Protozoa have a basically simple structure. These lower beings are composed of the primeval substance of life: protoplasm. But the forms which protoplasm takes are manifold. If some of the Radiolaria were not microscopically small, they might be described as Polyps. The Foraminiferae, if they were on a much larger scale, might well be called Molluscs, snails, and given a suitable and well-sounding name!

There are some primeval beings, such as the Flagellates (so called because they have longer, but fewer hairs that the other Ciliatae, such as Paramecium), which do not show clear distinctions between plants and animals. They often appear to be somewhat fish-like in form, yet they really have a tendency towards plant characteristics. That the demarcation between plant and animal is not sharply defined is a significant fact. Thus the Flagellate, Euglena, may be called a "plant-animal". This is a being which has green colouring, chlorophyll, and can assimilate as green plants do in the process of photosynthesis. Yet the Euglena is not static, as a plant is; it can move about freely as animals do. So the characteristic distinctions between plant and animal which are customary, do not apply. Plant and animal qualities are intermingled in one and the same individual in many of the Protozoa.

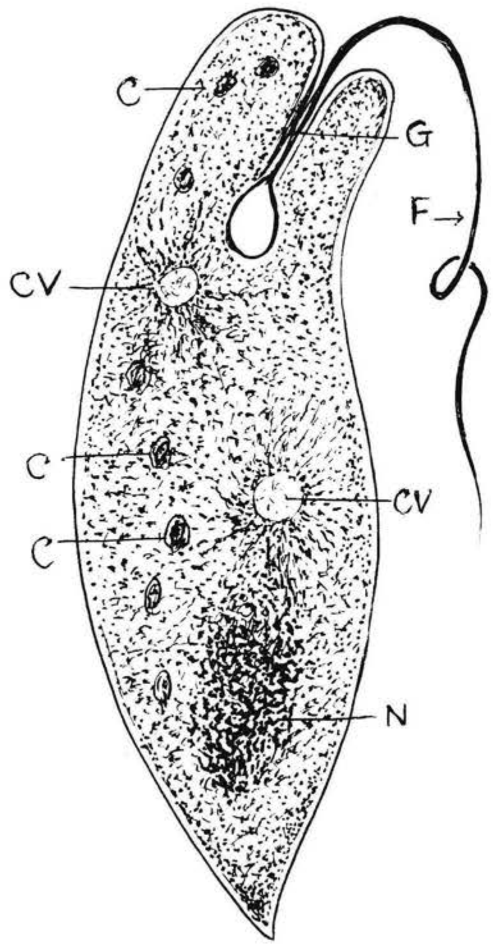

Fig. 1. Euglena viridis *(highly magnified)*
C Chlorophyll-containing Chloroplasts
CV Contractile Vacuole
G Gullet
F Flagellum
N Nucleus

If we try to apply the same measuring-rod to the kingdom of the lower beings, as we do to the whole range of the higher plants and animals we find that we cannot do so. We find that the differences between plant and animal are not so easy to define among the primeval beings. The most lowly creatures are sometimes plant-like animals, or animal-like plants.

If we look at some of these Protozoa under the microscope, we must remember that these creatures then appear on a much enlarged scale.* They consist of one cell only. Yet we can constantly see a resemblance to much larger animals. There is one of the Radiolaria, with five rays, like a Star fish. There are Starfish with such a five-rayed form, but they are much larger in size, are made of quite

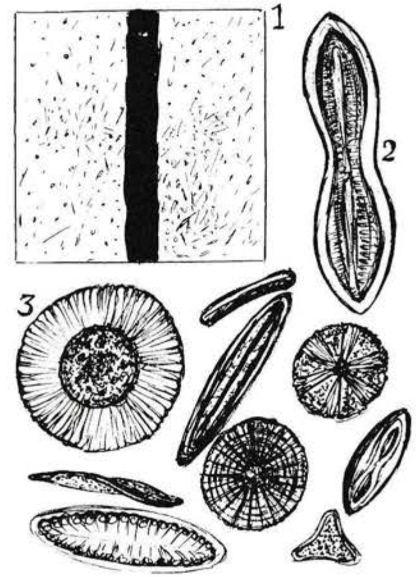

Fig. 11. Diatoms of different types.
Unicellular plants providing food for Protozoa in sea water.
1. Low magnification showing human hair (centre black), surrounded by diatoms in a drop of sea water;
2. Navicula viridula;
3. Plankton – mella sol and other diatoms, magnified much more highly than 1.

* Dr. Kolisko showed specimens and pictures at this point.

different material, and have a much more complicated structure than the Radiolaria. The silica skeletons of some of the Radiolaria are reminscent of snow flake crystals, with their six-sided, crystalline forms.

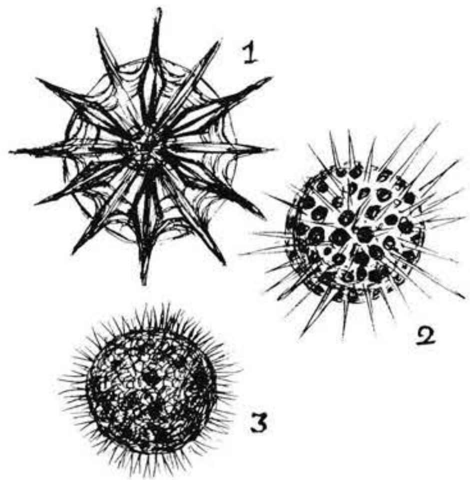

Fig. 12. Form and Matter. *(similar form, different substance)*
1. Snowflake – **Mineral**
2. Radiolaria protozoa – **Animal**
3. Volvox – **Plant**
(all highly magnified)

Nautilus was earlier thought to be a microscopically small cuttle-fish. Some unicellular creatures, like the Amoeba, are just a tiny lump of jelly-like protoplasm. On the other hand, there are unicellular creatures which develop **form** to a high degree, reminding us of higher organisms. It is possible to find all sorts of forms; some are like Fungi, others Jellyfish; others resemble Polyps or Starfish.

These are creatures of one cell only, but in them we can see the resemblance to much larger animals. This is the interesting and important question of the relationship between **matter and form.**

There are lower plants which remind us of the form of the higher plants, the same phenomenon which we find in the animal kingdom.

If we study the world of the Algae, we discover that in the lower plants there are resemblances, on a much reduced scale, to the higher plants.

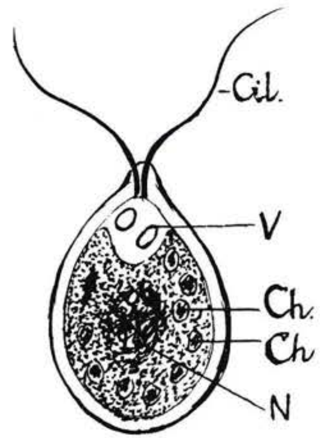

Fig. 13. Unicellular Algae *(highly magnified.)*
Providing food for fresh water Protozoa

Chlamydomonas angulosa
Cil – Cilia
V – Vacuole
N – Nucleus
Ch – Chromatophores

When, in a previous lecture, we were considering the Marsupial animals of Australia, I remarked that all possible types of mammals may be found among the Marsupials, but in a pouch-bearing form.* Besides the Kangaroo, there is a pouch-bearing wolf, a fox-like species and a pouch-bearing rat, and so on. Here again we have the impression that the animalic formative forces are entirely independent of the substance and of the stage of development of the being. So, too, in crystals of snowflakes, we again have the same impression that substance and form are independent. Thus the formative forces can appear in the most diverse materials.

* See Zoology for Everybody, No. 3. (Mammals) by Eugen Kolisko.

It would be an abstraction to state that Protozoa are **just** single cells. They are unicellular, but they are all individual living beings. It is only when we compare them with higher organisms, that we can appreciate and make sense of all that is comprised within the myriads of forms among the Protozoa. There is the basic Amoeba proteus, or the Flagellates, or the infinite variety of forms of the Radiolaria. What is split up in the world of the Protozoa into multitudes of living beings, all individuals, is linked together in the organisms of the higher animals and plants. Basically these higher beings are constructed of cells, every one of which has a boundary, a protoplasmic foundation and a nucleus.

The Protozoa may be individual, free moving cells, or they may be Protozoa which have put themselves at the service of higher organisms. We ourselves have within our bodies numbers of tiny living creatures: the white blood corpuscles. They live in Man as quite independent Protozoa. The yellow viscid matter produced by suppuration, pus, consists of such white blood corpuscles. The white blood corpuscles are like the Amoeba, of protoplasm and nucleus bounded by a skin. They devour all sorts of scraps. During the process of digestion they accumulate in great numbers in the blood of the intestines and support the assimilative process of the human being.

In one cubic centimetre of blood there are five million red corpuscles and also five thousand white corpuscles. If, by any chance, you were to meet a white corpuscle somehow, perhaps in a drop of water from a puddle, you would, on examining it under the microscope, think you had come across a new sort of Amoeba! You would not be able to distinguish it from an Amoeba found in a puddle of water! White corpuscles are, basically, completely independent Protozoa which live within human beings. They devour other tiny creatures. Pus is nothing else than such white blood corpuscles.

The red blood corpuscles are quite different. They have no nuclei. They have lost their nuclei and consist only of protoplasm. They are living beings which are in the process of decaying, of dying, of becoming corpses of cells. Red corpuscles have absorbed a mineral substance, and they stream to the lungs where they absorb oxygen, which has a destructive effect on them, killing them. This fact produces life in the organism as a whole. That the red corpuscles die, produces life elsewhere. The gall could not be produced if red corpuscles did not die, with the last remnants of their life taking in

oxygen and giving it out again. Red blood corpuscles are carriers of oxygen and of life only in so far as they themselves die in the process. We do not know of any other kind of cell which has lost its nucleus. In spite of the fact that red corpuscles have no nuclei, they may be regarded as the most highly developed cells in the organisms of the higher Vertebrates and in Man.

In human blood there are two types of cells, or we could say two types of Protozoa. One sort has kept the original structure: the amoeba. The others have been transformed and have given themselves up to the whole organism. They serve the breathing process. The two different types of cell are present in the human blood in a very highly evolved relationship. It is very interesting to study how Man has brought relationships between the white and red corpuscles into balance. This is in the connection between digestion and breathing. If a man climbs a high mountain, or lives in a district like the Himalaya Mountains, he has twice as many red corpuscles as the average number, because he must breathe more intensely. If he descends into the earth, working in a tunnel or a mine, the number of white blood corpuscles increases. Both lead to illnesses: "mountain-illness" and "tunnel-illness." There is a lack of balance between white and red blood corpuscles in both cases.

The human being must fight continuously against the cell; he must battle constantly against the cell principle. It is frequently said that cells are the building-stones of the human organism. In reality, cells are not the building-stones, but the enemies of the body. The process of incorporating cells into the human organism is an overcoming, rather than a building-up. The organism is not constructed by cells, in the way a wall is built up, with bricks. The human organism will be the more perfect, the less it does what the single cell dictates. If the single cell is the conqueror in the constructive process, then the result can only be a number of unicellular beings, Protozoa. Only if the single cell is conquererd and over-powered, can the Protozoa be led over to Metazoa. Man takes on the struggle against the cell-principle in the strongest way possible. This is best revealed in the red blood corpuscles. If the red blood corpuscles retained their nuclei Man could not maintain his self-consciousness and this would lead to the most severe form of anaemia. The human being must deprive the red blood corpuscles of their power; he must get rid of their nuclei, the controlling centres of the cells. This also applies to other kinds of Protozoa. Man must have bacteria in his intestines, but he must remove their strength. Why? Bacteria live as parasites in the intestines of higher beings. The higher organism overpowers the bacteria, and they are pressed down to a lower stage. They are conquered by the human being and the single cell principle is subdued. The bacteria act as servants to the higher organisms.

Every living being must pass through the unicellular stage. Every egg cell is a unicellular being; it is round in shape. Then there is the other cell linked with the reproductive process: the sperm cell. If, by chance, you came across a sperm cell in a pool of water, and examined it under the microscope, you would think it must be a Flagellate, and would classify it as such.

It is remarkable that Protozoa like those which live freely in the fluids of outer nature, also live within the bodies of the higher organisms and of Man; thus they are drawn into the service of more highly developed beings. These more evolved living beings must always pass through the unicellular stage, which is then overcome.

This can be observed when cell division takes place. The process of new growth is most interesting. What happens? Here is a tiny, piece of tissue from a growing onion bulb. With the aid of a microscope, we can observe how the process of growth takes place, following the changes in the individual cell at different stages.

First we see the cell, formed of protoplasm, with the denser nucleus in the centre, and the surrounding skin or cell-wall. (1)

The substance of the nucleus seems to thicken and become threadlike. (2)

The thread divides into a definite number of remarkable loops called chromosomes. (3)

These chromosomes cluster in the centre. A sort of centre is forming, at either end of the cell. (4)

The chromosomes split lengthwise. (5)

The half-chromosomes form into two groups, each chromosome is represented in each group. (6)

The new nuclei are beginning to form. The substance of the chromosomes links into threads. (7)

The threads now mass together, and there are two nuclei where there was previously one. (8)

Division of the nucleus is followed by division of the protoplasm and the cell boundary. (9)

There are now two cells where there was one before.

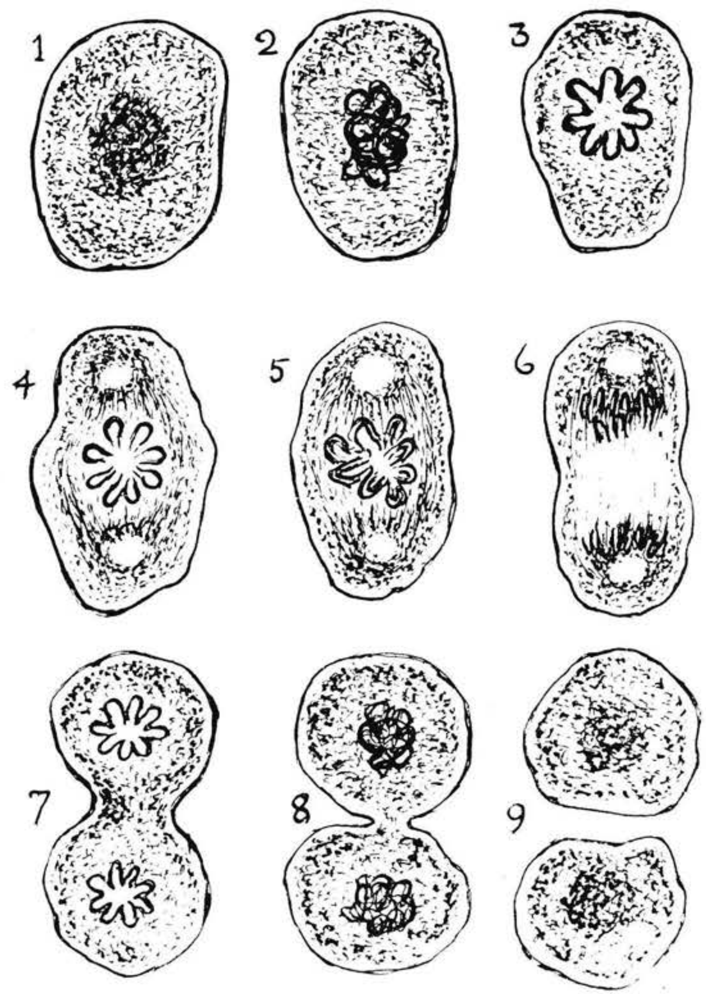

Fig. 14. Cell Division
Diagram of growth of cells in Onion bulb.

Every cell must pass through these stages when growth is taking place. What has happened? The single cell has been transformed into two. Before this could happen, the nucleus had to be dissolved completely; it had to be destroyed. Then something new arises.

If a more highly developed organism is to develop, the single-cell principle must be over-powered; then something new can come into being. This is called the "sun-stage". In every protoplasmic cell the nucleus dissolves and disappears and new nuclei appear; in every cell the "sun-stage" must take place during the process of growth. The isolating quality of the single cell must be erradicated. If something is growing, that is, perfecting itself, then the restricting process must be overcome. It must always be destroyed, otherwise nothing beyond the single protoplasmic cell could ever arise,and nothing could develop beyond the Protozoan stage.

There are living beings which have not developed the principle of growth, but always remain unicellular. That Protozoa swim about as one-celled creatures, indicates that they are beings which do not take part in the process of evolution.

Protozoa play a double role. On one side they are the animal world in minature. On the other side they live as cells in all the higher organisms. They serve to build up other living beings, in so far as they lose their unicellular character, and are themselves destroyed.

Then, too, there are multitudes of microbes, single-celled beings, which appear during illnesses of more highly-developed living organisms. The process of over-coming these microbes cannot always be achieved completely, not even in the blood which is the most highly organised substance to which living beings can attain. Thus we can understand how a variety of lower creatures may appear in an unhealthy organism, under abnormal conditions, which can lead to the destruction of higher living beings. It is true to say that there is continuous warfare between the more highly developed organisms of both plant and animal kingdoms and the unicellular beings or Protozoa.

Cancer, for example, is nothing but a kind of victory of the growth of cells over normal growth. The forces of the single cells become powerful, so that they increase without being controlled and taking on a form which belongs to a higher organism. Thus formless organs are produced which show a growth without limits. The unicellular principle prevails.

Protozoa are exceedingly widespread, and contribute to the construction of the earth itself. Radiolaria and Foraminiferae, or rather their remains, provide the material of the greater proportion of the outer layers of the earth's crust. The ocean beds are covered with these tiny living creatures and their remains. From this source, the substance of the earth is being continually augmented. But these unicellular creatures are detached from each other; they are "atomised" and, in the mass, produce a conglomerate without form.

In contrast, the higher organisms mould the living element of protoplasm in such a way that the nucleus, at the centre of each single cell, is overcome. At the same time we must remember that whenever something new is formed it is always in the form of an earthly sphere, at the beginning. But always the centre of this sphere must be dissolved, as development proceeds.

Nothing grows without sunlight. From the cosmos come innumerable influences as the sunlight shines down upon plants. These rays have a dissolving effect on the nuclei of cells, thus overcoming the earthly material principle within them. The forces of the cosmos work within the higher organisms in this way. Otherwise there would be no development towards form. There would be no progress from the Protozoa to the Metazoa.

Thus we may conclude by saying that the Protozoa are widespread over the whole earth; a multitude of unicellular creatures, of the greatest possible variety. They may be living as separate entities, in the watery element everywhere; or they may be confined within the organisms of other living beings.

From another point of view, we may look upon the Protozoa as a single animal group, which is the antithesis of the rest of the animal Kingdom; the Metazoa, both the Vertebrates and Invertebrates.

We may also consider the Protozoa as a kind of organic basis, into which the forces of the Plant, Animal and Human Kingdoms must work, in order to bring about a development of **FORM**, a progress from unicellular to multicellular, from Protozoa to Metazoa.

Thus, the Protozoa provide the foundation upon which other higher living beings may develop. Abandoned to themselves, they populate the world, penetrating the solid, fluid and airy elememts of the whole world.

The Protozoa are, indeed, a picture of the entire Plant and Animal Kingdoms, but split up into a myriad of archetypal forces.

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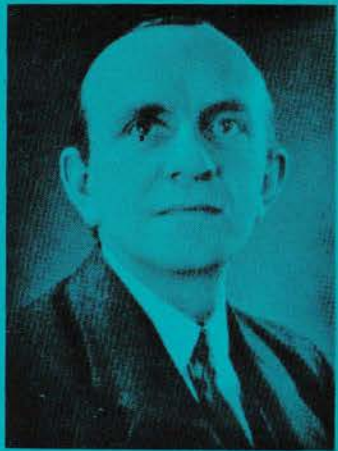

THE AUTHOR

EUGEN KOLISKO, one of Rudolf Steiner's most distinguished pupils, was educated at Vienna University as a doctor of medicine. He was also an authority on the Natural Sciences and History, and was a born teacher. As a lecturer in medicine, zoology, chemistry and history, he was much in demand, both in Europe and America. He died in London in 1939, at the age of 46.

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Zoology for Everybody

No. 5

Coelenterates Echinoderms

Eugen Kolisko

ZOOLOGY FOR EVERYBODY

A Series of Lectures

by

Eugen Kolisko
(M.D. Vienna)

6th and 7th Lectures
Coelenterates and Echinoderms.

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Introductory Note

Dr. Kolisko intended to write a book on Zoology, incorporating the material contained in his series of lectures given in 1932. This was not accomplished in his brief life.

Soon after his death, Mrs. Kolisko published the first two lectures. In 1944 she suggested sketches which might illustrate Lectures 3 and 4, on the Mammals, which we published in 1979.

Last year, with the help of Gladys Knapp, we were able to publish a further volume on the Protozoa - Zoology for Everybody No.4.

We are again greatly in Gladys Knapp's debt for her continued efforts in translating and sketching the material for this booklet.

A. Clunies-Ross. Bournemouth, January 1981

List of Illustrations

ZOOLOGY FOR EVERYBODY
LECTURE 6

THE COELENTERATA

Another group of animals will be our study today. They are almost exclusively marine creatures. Some may be found swimming freely in the seas at different levels. Others live firmly anchored to rocks in shallow waters, or on the ocean beds. They are so widespread and numerous that they form an integral part of the world's oceans. They take on the most diverse forms, and live as whole forests in the depths of the seas.

The name of this large group, Coelenterata, means HOLLOW. These are soft-bodied, hollow creatures, and the characteristic common to all members of this group is that their basic form is a SAC, that is a cup-like shape of soft material. The Coelenterates include hydra, corals, sea anemones, jellyfish and sponges. Some can unite to form colonies and occupy large areas of the sea. The corals are creatures of this type. There are delicate, soft corals which are transparent; more substantial ones of a fleshy texture, and those which represent the stony corals. These are found especially in the warm waters of the southern oceans, and we know them as the builders of coral reefs such as the Great Barrier Reef of Australia.

The Sea Anemones are single polyps. These are 'flower animals' with their brilliant colours. It was only in the eighteenth century that they were discovered to be animals; previously they had been considered plants. An exceedingly manifold world of colour is spread out in these transparent creatures of the oceans:

reds, greens, blues, in no way inferior to the colours found in the blossoms of plants. They are 'swimming flowers' and have often been described as such.

The Medusae are very interesting creatures and we will begin our more detailed study with these. The Aurelia is a medusa (commonly called a jellyfish) which appears in vast numbers, especially in the North Sea. Aurelia is one of the kinds of jellyfish

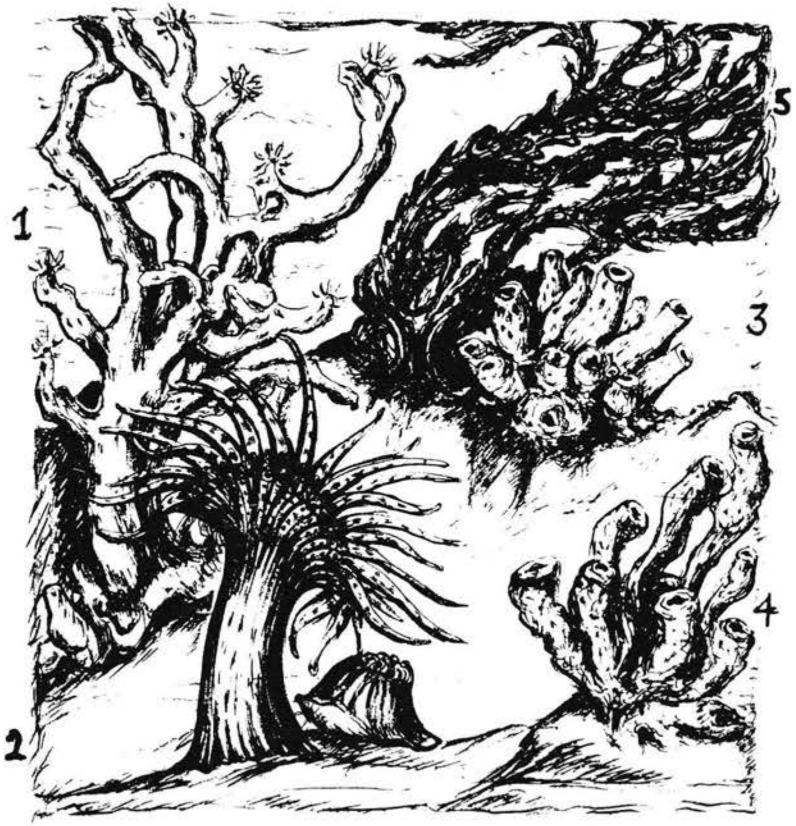

Fig.1 Marine Coelenterates
1. Precious Coral (*Corallium*) 2. Sea Anemone (*open and closed*)
3. Sulphur Sponge 4. Bahama Sponge
5. Seaweed – Fucus serratus

most commonly stranded on British shores. It is a transparent medusa, usually three to six inches across. It is shaped like a rather shallow bell, or an inverted saucer. It is difficult to distinguish it from the surrounding sea-water, since its body is formed from a transparent jelly-like substance, protoplasm, which is 90% water. It swims by a rhythmic series of contractions of the bell. Beneath there are tentacles dangling in the sea-water; they surround the so-called mouth. Such an animal can eat small water creatures, seizing them with its tentacles. It is easy to see the structure of the jellyfish as the creature is transparent. In the centre of the inverted saucer shape there is a hollow space. What is this cavity? It is nothing else but the stomach, in which any food, captured by the tentacles, and wafted into the mouth, is digested.

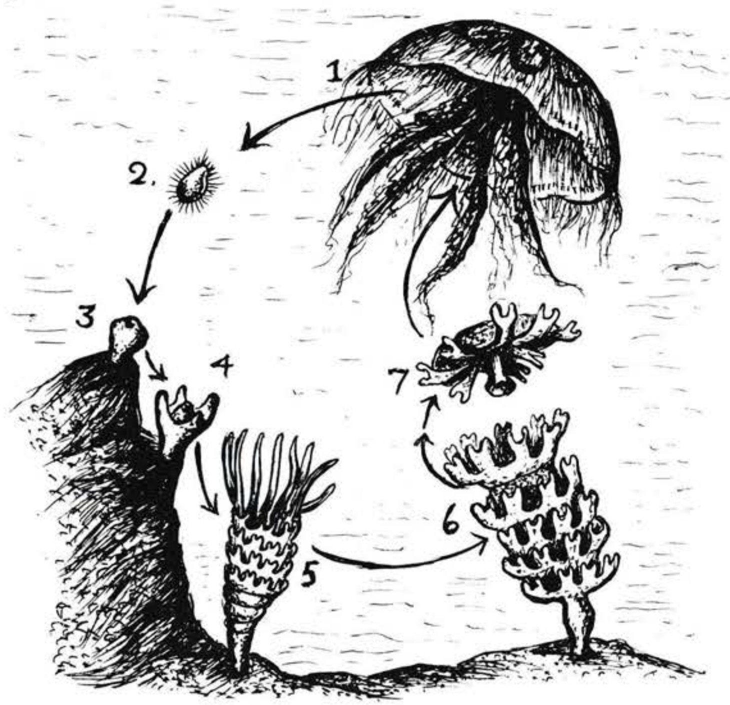

Fig.2 Life Cycle of Aurelia aurita
1. Free swimming Medusa (*sexual stage*) 2. Ciliated Larva (*planula*)
3 and 4 Young polyps 5. Asexual stage
6. Ephyra 7. Ephyra medusa stage.

The many different kinds of medusae (or jellyfish) can move through the water quite quickly by contracting and expanding the bell-like form rhythmically all the time. Some pulsate like a heart, The tentacles are covered with many little structures which look like warts. These are stinging organs. If touched they eject a spiral thread, with a fluid which stings, giving a burning sensation, like the hairs of a stinging nettle. Stings from a jellyfish can produce a severe rash in human beings and can have even more serious effects. The albumen substance of the lower animals has a poisoning result on human blood. Many of the more lowly creatures have such stinging structures, the so-called nematocysts, which the jellyfish have.

Aurelia aurita passes through a strange and interesting development which is typical for other Coelenterates of the medusa type. Within the bell shape, eggs and sperm cells are produced after a certain time. After fertilisation the resulting eggs are released into the sea water. They develop and become ciliated

Fig.3 Compass Jellyfish
Swimming by contracting bell – common in Atlantic.

larvae, rather like some of the ciliated Protozoa, except that they are larger. After a while, each larva swims about and then turns inside out to what has become a little sac. Through this inversion the larva has become what is known as a polyp. It ceases its mobile activity, attaches itself to a firm anchorage, and becomes a polyp, like a miniature Sea Anemone. The polyp is now an organ which functions as a stomach absorbing nourishment, and increasing in size. The polyp now has a strange capacity. It sprouts buds, which produce miniature structures which are saucer-shaped. These are called ephyrae, and they have an eightfold radial shape. The ephyrae pile up one over the other like a stack of plates. Then the top ephyra separates from the column and floats away, turning inside-out as it does so. The result is a miniature Aurelia jellyfish, a medusa. After a while the new Aurelia medusa produces eggs and sperm within its bell-shaped form. After the fusion of an egg and sperm, the resulting larva (the so-called planula) floats away into the sea water, turns inside-out, ceases to be mobile, settles down and anchors itself firmly to a rocky base. The **planula** is now a polyp, a sac-like, immobile form which merely digests. After a while it produces buds vegetatively, which become a stack of ephyrae. These become Aurelia medusae.

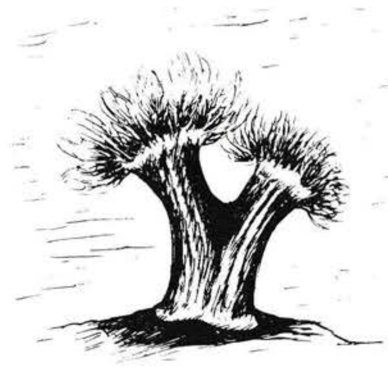

Fig.4 Sea Anemone – *Metridium*
Dividing to form two new individuals – Bermuda.

So we have the peculiar happening of a rhythmic process which produces alternately medusa, polyp, medusa, polyp.......So you can see that the polyp has a kind of vegetative reproduction similar to that of plants. Just as the plant puts forth leaves, so the polyp sprouts new Aurelia medusae; this is an asexual method of reproduction. The polyp is firmly anchored and immobile; it merely digests and propagates asexually.

The medusa is more complicated in structure; it is free-swimming, and has a sexual method of reproduction. So the Aurelia is a very interesting creature, because it shows the metamorphosis of a polyp into a medusa; and a medusa into a polyp. The polyp and medusa generations alternate, and each Aurelia individual resembles its grandparent and not its parent. This is called **alternation of generations**.

The Aurelia polyp starts off as a single cell, the egg-cell. After fertilisation the number of cells increase, by cell division, and form a hollow ball. The hollow ball turns inside-out and forms what is called a GASTRULA. At this moment the animal begins to digest. At this very early stage of development, the creature consists of two layers of germinal cells, an inner and outer layer: the endoderm and the ectoderm.

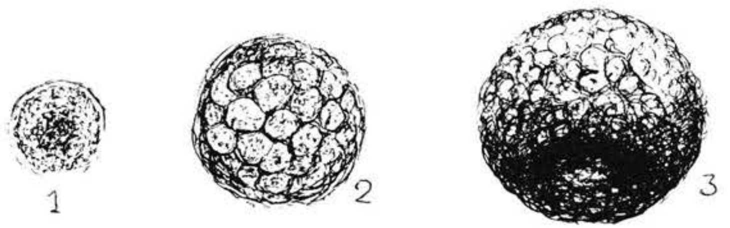

Fig 5. Blastula and Gastrula
1. Egg Cell 2. Blastula (*hollow sphere*) 3. Gastrula (*inversion to form sac*)

Ernst Haeckel considered the gastrula a kind of archetypal form of the animal kingdom. He made the discovery that every animal which starts from an egg cell follows this development. Only with the higher animals the process sometimes becomes masked, as other organs than the stomach begin to develop.

The Coelenterates only reach the gastrula stage of development. They merely consist of a devouring stomach, nothing else.

If we value rightly the importance of the 'turning-inside-out' process which produces the gastrula, we see that it is an important turning-point in the evolution of the plant and animal kingdoms. The inversion which results in the gastrula can take place only in animals, never in plants.

There are some so-called 'carnivorous' plants such as the pitcher plants and other insectivorous species. But not one of these meat-eating plants has a stomach formation. The surface of such a plant exudes a juice which traps and then dissolves the captured insects. Only a being which has a stomach can have the instinct of feeling hungry and of eating. When the gastrula is formed by an inversion process, there is a complete breaking away from the plant-like development.

Haeckel discovered something of enormous importance when he saw that the fundamental form of any animalic creature is the gastrula, with its formation from two different kinds of cells, the inner and the outer. The inner layer has the function of digesting;

Fig.6 Plumatella funguosa – *Sea-moss found in stagnant water*
1. and 2. enlarged 3. Natural size.

the outer layer of cells is sensitive. The outer layer forms the little stinging wart-shaped capsules, the nematocysts. Although these do not form a nervous system, they do play a somewhat similar role. So there is a contrast in the functions of the inner and the outer layers of the gastrula, which could not take place in a plant. It is obvious that something is trying to incorporate into the animal, which cannot do so in the plant.

Not every Coelenterate goes through the life-cycle of Aurelia aurita, with alternating medusa and polyp generations. Some Coelenterates are so small that they cannot be seen without the aid of a magnifying glass. The Sea Mosses are tiny polyps which never have the stage of development of a jellyfish or medusa. A cursory glance gives the impression that they are plants. But with a magnifying glass it is possible to see the little polyps extending their tentacles in search of food.

The Sea Mosses are mostly marine, but there are a few fresh water species which live in ditches and ponds. They are colonies of polyps, minute in size. The polyps can retract into tiny cases, which are so arranged in thread-like strands, that when these are grouped together they produce a moss-like encrustation. They could easily be mistaken for corals or seaweeds. If the tiny polyps are disturbed, they retract in to their individual cases and nothing can be seen of them.

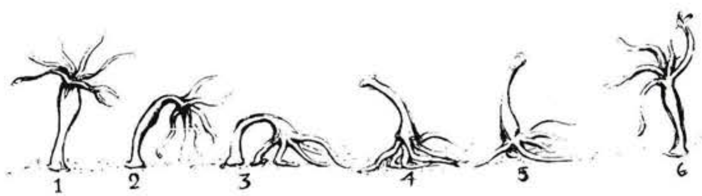

Fig.7 A Hydra moving by somersaulting along floor of aquarium.

There is not always a clear demarcation between the plant and the animal kingdoms in the most lowly stages. There are 'plant-animals' and 'animal-plants'. Plants have green colouring matter, chlorophyll, through which they can produce food by the process of photosynthesis. Animals have no chlorophyll. But some animals have been considered plants. Such a one is the fresh-

water polyp, the Hydra called **Chlorohydra viridissima**, to give its official name. There are several species of Hydra, such as the transparent one often found in ponds. This little Hydra can be seen moving along the floor of an aquarium by somersaulting; it is colourless and transparent. But Chlorohydra viridissima is green. Apart from the fact that it is green in colour, this larger Hydra is typical of a pure polyp. Such polyps never reach the stage of a jellyfish or medusa.

The green colour is interesting. It is difficult to decide whether this arises from the green Algae which it eats and digests only partially, or whether the colour is its own nature. Many volumes have been written discussing this question. Some unicellular creatures, the Protozoa*, do live within other beings, working for the more highly developed organisms in some way. The Algae, which includes the seaweeds, as well as green unicellular and thread-like fresh water species, are the most lowly members of the plant kingdom. They provide food for some of the animalic creatures.

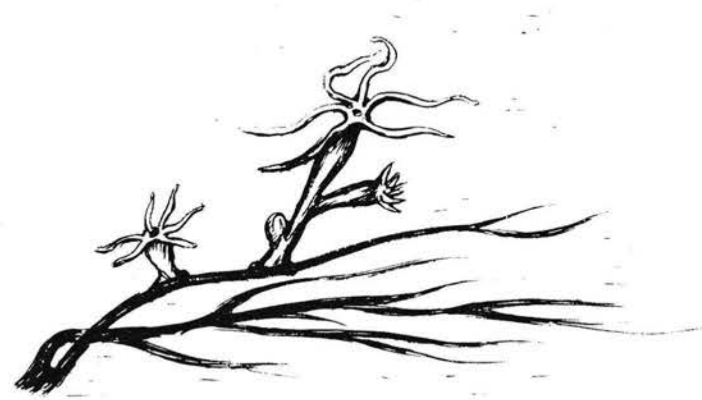

Fig.8 Fresh Water Hydra – Chlorohydra viridissima
On water-weed – shows vegetative budding.

*See Zoology for Everybody No.4 – Protozoa by Eugen Kolisko.

We can see how the polyp type of Coelenterate has certain plant-like characteristics. It is not free-swimming like the medusa, for example, but is anchored like a plant. It is difficult to distinguish between plants and animals in the lower stages of the plant and animal kingdoms. Sometimes there is an intimate partnership, a 'living-together' or symbiosis. An example is the lichens, in which an Algae and a Fungi interpenetrate each other so thoroughly that they form one organism. A parallel can be drawn between the Polyps and the Algae. The marine forests consist partly of seaweeds and partly of corals and other animalistic creatures, and they are so closely interwoven that it is difficult to distinguish between them.

The seaweeds in the depths of the ocean are red or pink in colour. Those living in more shallow seas are brown, like the well-known Bladder-wrack, or Fucus serratus, which is also common. Seaweeds living on rocks between low and high tide marks are often green, like the Sea Lettuce. Green Algae often penetrate into fresh water and may be found in ponds and ditches. The Coelenterate animals and Algae plants can interpenetrate each other and this is what happens in the fresh-water Hydra, Chlorohydra viridissima.

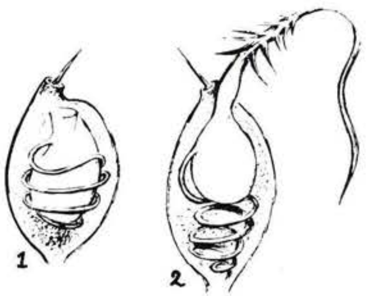

Fig.9 Stinging Capsule of Hydra
1. Undischarged 2. Discharged.

The Hydra has strange qualities. In the eighteenth century, the movements of its tentacles caused it to be classified as an animal. As an experiment, the creature was cut into pieces, and it was found that each part could grow into a new Hydra. It was also turned inside-out, with the result that after a while, the former inside tissue developed nematocysts, whilst the former outside

tissue took over the function of digestion. This experiment proved what powers of regeneration and adaptation there are in the Hydra.

There are other creatures of the Polyp type, as well as the Hydras. The Sea Anemones are Polyps on a larger scale. There is an immense number of kinds of Sea Anemones. They live on sea-beds and on rocks in shallow water, and form great 'flower' gardens of many colours, though they are definitely animals. Sea Anemones are basically a soft sac, with a fringe of tentacles at the top, which surround the mouth. The tentacles are beset with stinging nematocysts, which capture any small creatures wafted towards them in the sea-water. The interior of the Sea Anemone is partitioned into a number of alcoves, each of which is a stomach; in this way a larger digestive surface is provided than would otherwise be available. The Sea Anemones live as independent, individual polyps.

The corals are polyps on a much smaller scale, and they live in groups. We have already mentioned that there are several types, delicate flower-like ones; those of a fleshy texture and the stone corals. The stone corals secrete quantities of lime, and include many different kinds, such as mushroom corals, brain corals and organ corals, named from the structures they leave behind. The organ coral can form immense rocky structures shaped like organ-pipes, and produce reefs such as those of the Great Barrier Reef in the Southern Pacific Ocean.

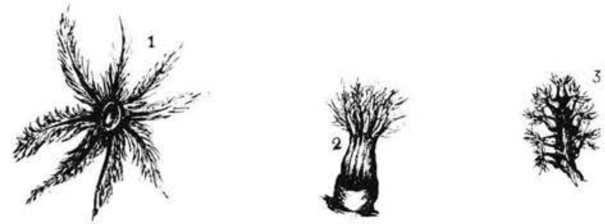

Fig.10 Single Polyps of Precious Coral
1. Mouth surrounded by eight feathery tentacles 2. Side view of one polyp in limestone cup 3. A cluster of polyps.

Corals are very much affected by light and by temperature conditions. Usually the polyps retract out of sight during the day, and only expand and feed during the night. They can only thrive in a certain degree of warmth and where they can find a sufficient supply of Carbon-dioxide. Hence they are only found in the warmer southern oceans. Great masses of rock have been built from the limestone remains of the cases of coral polyps. Carrara marble was created in this way.

Some corals are used as jewellery. These are the remains of certain stone corals which permeate the limestone with a red substance. This coral is a 'precious stone' produced by an animal, just as the pearl is.

Polyps can produce a colony as can be seen with the coral polyps. It can also happen that Medusae can form a group or colony. An example of this is Physalia, the so-called 'Portuguese Man-O'-War'. One medusa becomes inflated with air and rises to the top of the group, and thus acts as a float. The whole colony becomes one organisation, and floats on the surface of the sea. It is an impressive sight, very mobile and colourful, usually in shades of blue, with some red. It sails along, carried by the wind, like a ship under full sail. Meanwhile the tentacles of all the jellyfish in the group trail in the water below.

Fig.11 Portuguese Man O'War – *Physalia*
A colony of medusae.

Now-a-days Zoology and Botany are often considered separate subjects and are studied independently. We are accustomed to separate different living beings, whereas in reality they form a unity and should be considered as such. The Coelenterates or 'plant-animals' are closely connected with the Seaweeds and other Algae, especially in the midst of the oceans. We can best understand these relationships by studying the various organisms which have the Medusa...Polyp...Medusa.. Polyp... alternation of generations. The Medusae are free-swimming and unattached, and therefore more truly animal than the static, anchored Polyps which are more plant-like. There is an immense range from the delicate medusa forms such as Bougainvillea (sketched in Fig.12) to the stony corals which are heavily impregnated with limestone and so are of a coarse, stone-like texture. Bougainvillea has a tree-like appearance in its static form, with polyp colonies. It also produces free-floating colonies of medusae (Fig.13).

But the basic form of the Coelenterates is always the same hollow sac, which in reality, is merely a devouring stomach. The Coelenterates are the most lowly group of the animal kingdom

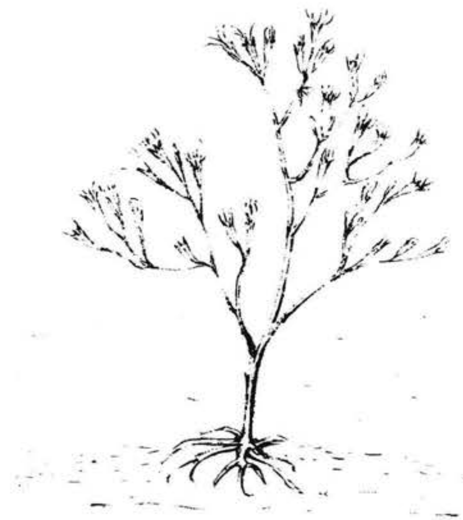

Fig.12 Fixed Colony of Bougainvillea Polyps

among the Metazoa (multicellular), just as the Algae are the most lowly group of the plant kingdom. All the forms found in the plant kingdom: trees, bushes, leaves, and flowers can be found among the Coelenterates in the most varied colours. The only difference between the two is that the animals capture prey with their tentacles and devour them.

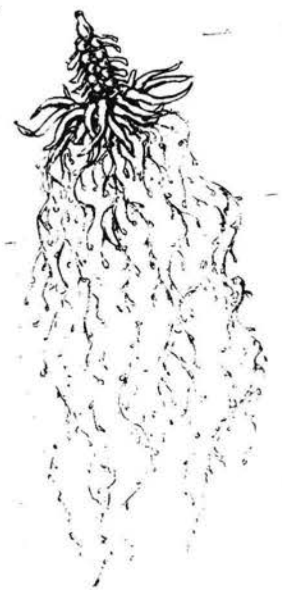

Fig.13 A Colony of Bougainvillea
free floating medusae

There is one more group usually included in the Coelenterates in most classification systems. This group is the sponges. These are the most primitive creatures. They consist only of a sac, with many surrounding hollow cavities in the soft body. The sponges have no nematocysts (stinging organs) with which to catch prey. They are anchored to rocks or to some other firm base. All they do is to allow themselves to be permeated with water and whatsoever it contains. They are so-called 'filter-feeders', and digest whatever is wafted to them. They have no other activity.

There are several types of sponges: horn sponges; silicon sponges; and chalk sponges. In the first type, horny sponge fibres form an interlacing network, which provides support for the soft walls of the sponge. The Elephants Ear Sponge, found in the Mediterranean Sea, is an example of this type. In the glass sponges, such as the Venus Flower Basket, which grow only in deep marine waters, it is spicules of silicon which provide support. Calcareous sponges are common in shallow sea waters of the temperate regions. These sponges are mostly small and bristly in texture.

Fig.14 Seaweeds
Green Sea Lettuce (*ulva lactuca*) – Brown Fucas serrat . – Red Chrondus crispus

So we have completed a brief survey of this great group of animals, the Coelenterata. This is the most lowly group of the Metazoa, creatures consisting of more than one cell. They are characterised by the polarity between the inside and outside of the organism. These animals are composed of two layers of tissue, the endoderm and the ectoderm. The basic plan of the Coelenterates is a cup, the outer layer of which is formed by the ectoderm, and the inner by the endoderm. The difference begins between the digestive and the nervous system, the latter forming the outer layer. Haeckel applied his knowledge of embryology to a study of this phylum, and realised that the stage in embryonic evolution in which the embryo loses its spherical shape in order to form something like a cup, and is called a gastrula, can be compared with an adult hydra. They are free-living beings corresponding to the gastrula stage of embryonic life.

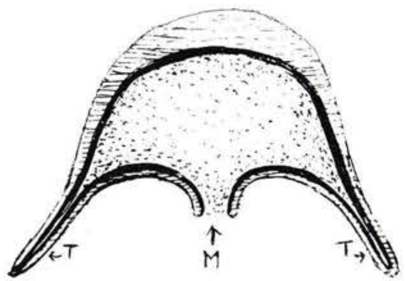

Fig.15 Section through Medusa
M Mouth T Tentacles
Black – endoderm tissue. Shaded – ectoderm tissue. Dotted – hollow cavity.

In the Coelenterates the difference between the animal and plant kingdoms becomes evident. With a dualism, characteristic of the Coelenterates, the two types of Polyp and Medusa are produced. The fixed mode of life of the Polyp leads towards a plant-like, vegetative growth and solidification. The other path,

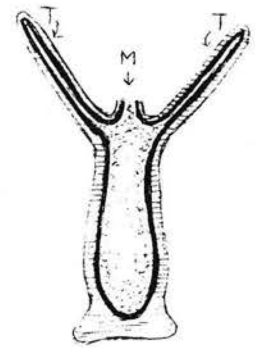

Fig.16 Section through Polyp
M Mouth T Tentacles
Black – endoderm tissue. Shaded – ectoderm tissue. Dotted – hollow cavity.

the Medusa, leads to mobility, to soft and pliable tissues, to sexual differentiation and a more animal-like condition. So we find **dualism** appearing in the anatomical structure, in the endoderm and ectoderm, in the nervous and digestive systems and in the polarity of the polyps and medusae, and also in the division of the species into fixed colonies of the coral type and floating colonies of medusae.

———★———

ZOOLOGY FOR EVERYBODY
LECTURE 7

THE ECHINODERMS

Last time we studied the polyps, corals, sea-anemones and jelly-fishes. They are all creatures found in the sea in large numbers. We might describe them as a kind of animal forest in the sea. These creatures share the sea with certain members of the plant kingdom: the seaweeds or algae. These, too, are spread throughout the seas, both in shallow and in deep water. Apart from unicellular algae, the seaweeds are the lowest members of the plant kingdom. These, with the groups of animals just mentioned, form the **Flora** and **Fauna** of the sea.

Popular knowledge about these creatures is not very accurate. The same is true of the animal group we are studying today: the Echinoderms or prickly creatures, of which the Starfish is an example.

Haeckel was one of the first who, in his work on Arabian corals, described the marine forests of the Red Sea. He was provided with a suitably equipped boat, and not only wrote about the coral forests he found on his expeditions, but also painted them in wonderful colours. He writes: "It is not possible to describe the splendour of the under-water scenes, neither with my pen nor in my paintings. Before I set out on the expedition I read some enthusiastic descriptions by Darwin and others. These prepared me to have great expectations, but the reality surpassed everything! Even a landscape full of flowers just coming into bloom cannot give any idea of the splendour of the marine forests in the depths of the sea!" Francé, while on his travels in the Adriatic Sea, described the marine forests there: "To have a true understanding of what the flora and fauna of the sea are like, one must travel in a rowing boat along the rocky sea-coast....."

I have travelled in this area, and saw for myself the underwater landscapes so vividly described by Francé. This is the world we enter when we observe the seaweeds, and the plant-like animals. It is an animal group into which are inter-woven other types. The Starfish stands out as an individual type among these. These prickly sea-creatures which we will study today are the Echinodermata, of which the Starfish is a characteristic example. Observation of the Starfish shows the qualities which are characteristic of the group. It is a typical Echinoderm, a remarkable creature, unique in the animal kingdom.

Starfishes are numerous in most seas, and are especially common in the Adriatic. They have the capacity of leaving the water and can crawl along the shore. They are quite lively and mobile, though this is not at all obvious from the form of their skeletons. The Starfish has two striking features: the skeleton and the outer covering of the creature. Little prickles cover the whole surface. Closer observation reveals that, in reality, these 'prickles' are little tubes which are suckers. These fill with liquid and then become empty again, and this is the process which enables the creature to move. The Star-fish has disc-shaped clasps as well. We see how useful these are if we observe a starfish in an aquarium, and note its ability to climb up vertical walls. The regular geometrical form of the star-fish is astonishing; it has a five-sectioned radial symmetry. The five 'arms' help the starfish to be mobile, and it can move quite rapidly. It has no front. no back; no left, no right; only above and below. The mouth is on the underside; the excretory orifice on the upper side.

The tips of the arms are always turned up when the starfish is moving, for the five 'eyes' or 'places sensitive to light' are at the ends of the arms. The Starfish is a most extraordinary creature; practically everything about it is fivefold. It has five arms, which surround and enclose the mouth. The eyes, usually found in the heads of other animals, are distributed over the periphery of this remarkable creature. The starfish may be described as a head, in which the parts are arranged radially in a very pronounced

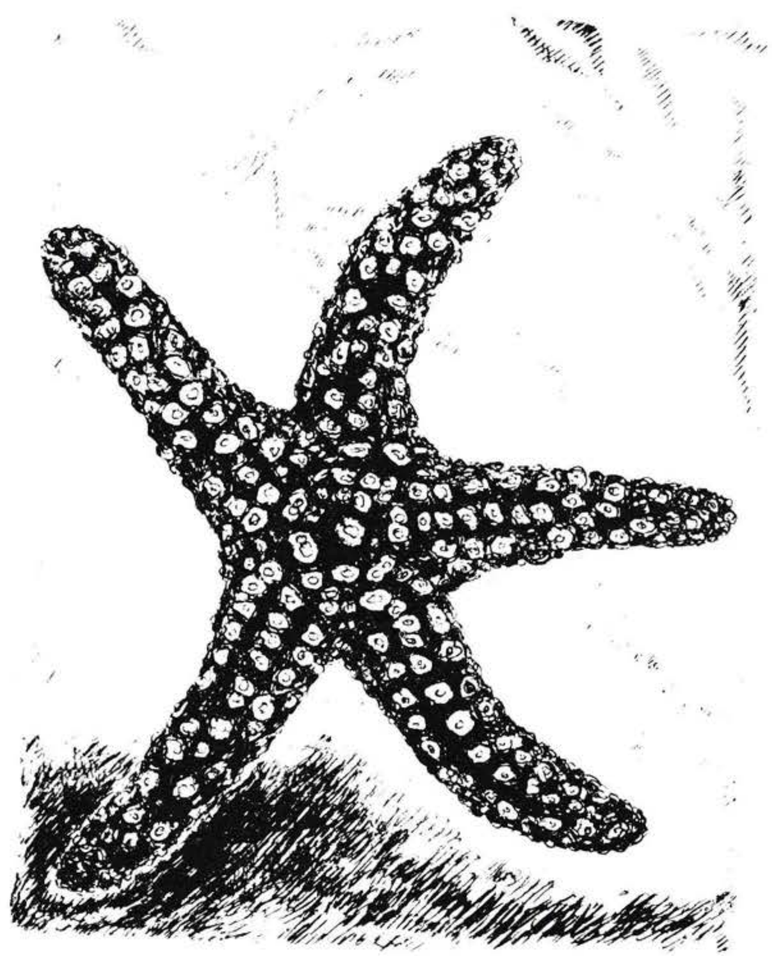

Fig.17 Starfish Astercanthion
From Atlantic Ocean

geometrical form. There is no other animal with which the starfish may be compared.

Starfish may be found in the most varied colours imaginable: brilliant hues of red and purple, and also in black. Some starfish are blue with a tinge of purple. It is characteristic of the Echinoderms, the prickly creatures, that they appear in strong brilliant colours, much more vivid than those of the corals. These creatures may be found in a variety of colours, all of which are much more delicate in tone than the brilliant hues of the starfish. The covering of the starfish is a tough, leathery, substance. Some starfish have great, strong horn-like prickles; others have small protuberances more leather-like in texture.

From the anatomical point of view, the starfish has a strange unusual structure. Externally, the most characteristic and striking feature of the starfish and other Echinoderms is the radial symmetry; the five rays give a pentagonal form. This fivefold quality is also to be found in the internal structure. The digestive tract has five sacs, the so-called 'livers'. The nervous system is shaped like a five-pointed star. The skeleton of the mouth consists of multiples of five teeth, the so-called 'Lantern of Aristotle'.

We have already described how the Coelenterates, in their early stages of development, are composed of two germinal layers of tissue, the outer ectoderm and the inner endoderm. These result in an outer nervous system and an inner digestive system. The Coelenterates are basically a devouring sac, nothing more.

If the Echinoderms had remained at this stage, they would not have been able to evolve any true internal organs, apart from a digestive tract. But the Echinoderms have THREE germinal layers, the inner endoderm, the outer ectoderm, and between these two a middle layer, the **mesoderm**.

As the Echinoderms develop, a rhythmic system is produced from the mesoderm. This is a strange organisation, which only the prickly creatures, such as the starfish, the sea-urchins and the sea-cucumbers possess. This special rhythmical organisation is the so-called AMBULACRAL system, which combines the functions of blood-circulation and locomotion.

There is a lime plate called the **Madreporite**, which has sieve-like holes. From this proceeds a ring-shaped tube, the stone-canal, which encircles the stomach. This ring, the stone-canal,

has five side-canals, on which cling, like grapes on a stalk, little sucking feet, which project on to the outside of the starfish. The sucker-feet are filled from the ambulacral fluid, and in this way become inflated.

It is difficult to say just what the composition of the ambulacral fluid is. Sea-water enters from above, and it is really a

Fig. 18 Starfish *from Pacific Ocean*
1. Serpent Starfish 2. Sun Starfish (*red*) 3. Australian Starfish (*violet*)
4. Malayan Starfish (*pink with black spines*)

combination of sea-water and lymph, because it contains colourless blood corpuscles. The ambulacral fluid and its origin explain the great similarity between sea-water and blood. It is interesting that all medical injections have to be prepared in a saline solution because of the similarity between sea-water and blood.

The ambulacral system enables the starfish to breathe, for air enters with the sea-water. It also enables the creature to move, for the sucking feet are used for locomotion. Thus this strange organisation, the ambulacral system, is a combined breathing-movement-circulatory system. The circulatory system is imperfect, for it is a water rather than a blood circulation. Thus organs for breathing, for circulation and for movement arise from the middle layer of germinal tissue, the mesoderm.

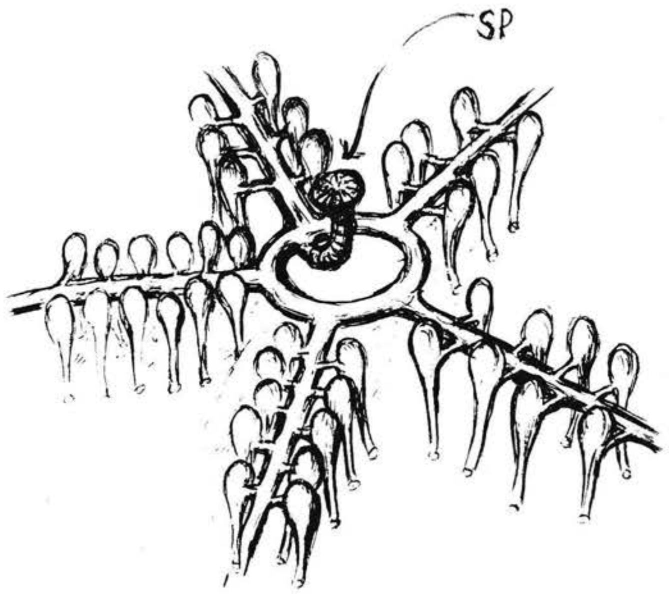

Fig.19 Water-vascular system of Starfish
The ring canal has five radial branches bearing the tube-feet
SP sieve plate

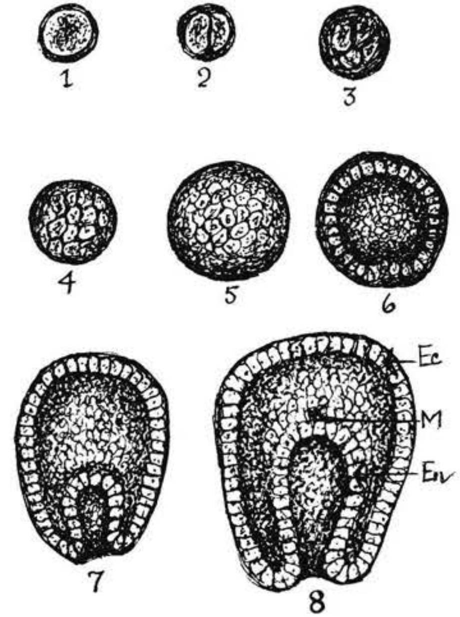

Fig.20 Development of Sea Urchin (*early stages*)
1. Single cell 2-4. Cells increase 5. Blastula
6. Section through Blastula 7 and 8. Section through Gastrula
Ec Ectoderm M Mesoderm En Endoderm

The nervous system, developed from the outer layer, the ectoderm, also has a five-radial symmetry. From around the mouth branches of nerves radiate to the organs of sight at the ends of the five arms, and also create sensitivity for touch.

The Echinoderms have a much more complicated structure than the Coelenterates, in which the whole animal is really only a stomach.

All living creatures originate in a single cell. The number of cells multiply through cell-division, until there is a spherical mass of cells. A cavity develops as the **Blastula** stage forms. The Blastula is in the shape of a hollow ball. The cavity tilts inwards and the next stage, the **Gastrula** succeeds the Blastula. This is the level of the development of the Coelenterates, which are merely devouring sacs.

Higher development takes place when something is held back, when forces are reserved from the digestion, from the mere devouring process.

The Coelenterates have TWO germinal layers of tissue, the endoderm and ectoderm. The prickly creatures, the Echinoderms, have THREE germinal layers, the endoderm, ectoderm, and a middle layer between them, the MESODERM. The development of the digestion system is restricted to a certain extent, and the arms of the starfish are set free for movement, for it is not necessary to use them in the nourishment process. The creature can move towards its food. It is not fixed and static as some sea creatures are and thus is not dependent upon passive acceptance of whatever food wafts towards it.

The Coelenterates depend on what is brought to them in the sea water. The starfish is more highly developed. From the extra germinal layer, the mesoderm, the starfish develops, in a primitive way, all the organs that the higher animals have, and even all that human beings have. But these organs are only rudimentary and are arranged radially in the starfish. We have described how the Coelenterates only reach the gastrula stage of development. The human embryo passes through a gastrula stage very briefly. Practically all its potential is reserved for higher development, and thus human blood is formed. It is very interesting that the functions of blood-circulation and movement are linked at such an early stage of embryonal development. In the Coelenterates, such as the sea-anemone, the tentacles around the mouth are affected by the movement of sea-water and thus waft food into the sac-like stomach. In the more highly developed Echinoderms, the extra germinal layer the mesoderm, produces the ambulacral system, a combined breathing - movement - circulatory organisation; which is linked on to the digestive process, and the nerve system. Thus at a very early stage of embryonal development the digestive, circulatory and nerve system appear together.

There are many varieties of starfish. Some have six arms, others ten or more, but by far the great majority have a five-radial symmetry. All are brittle, some more so than others, but all have the capacity to replace damaged parts; lost limbs are replaced by new growth.

The Sun starfish is an example with ten or more arms. The Serpent starfish also has many arms, but these are very long, and its body is very small. Because the digestive tract in the Serpent starfish does not extend into the arms, these are very flexible and mobile and frequently become entangled. This gives it a very unattractive appearance and it is sometimes called the Gorgon starfish, because the tangled arms resemble the snake-like hair of Medusa. It is interesting that the Serpent starfish is so mobile and flexible. The digestive process always has the effect of slowing things down; it produces a certain laziness. In the Serpent starfish the digestive tract is restricted to a certain extent.

The **Sea Urchin** is a near relative of the Starfish. It has long prickles, which look like stilts, and it uses them for climbing about. It has an ambulacral system. With the aid of little sucker-feet and prickles, the Sea Urchin can move about very cleverly. Imagine that the five arms of a Starfish are brought together, and linked by the five tips; this is the form of the Sea Urchin. It is obvious from the structure of the shell of the Sea Urchin that it is a metamorphosis of the Starfish; the edges of arms of the Starfish have been, as it were, linked together. The Sea Urchin moves

Fig.21 Test or skeleton of Sea Urchin

quite differently from the Starfish. Though it grows longer prickles and moves differently, the Sea Urchin has a similar anatomy to that of the Starfish, but its digestive system does not extend into the arms. It still has the fivefold geometrical form which is the most characteristic feature of the Echinodermata, the Starfish family.

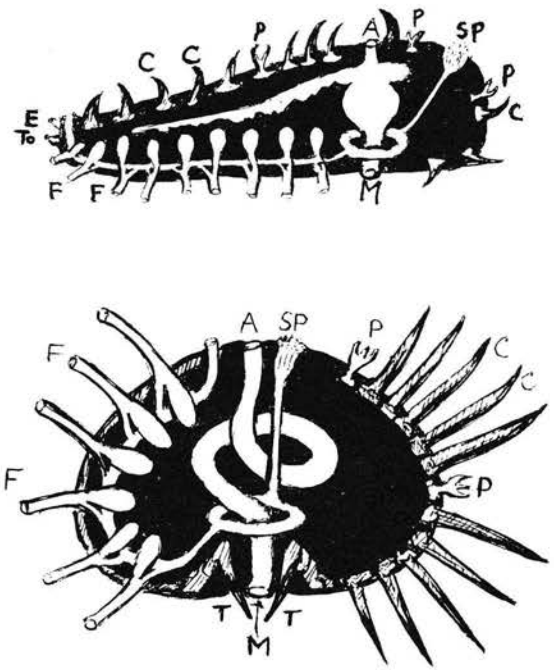

Fig.22 Sections of arm of Starfish and Sea Urchin
Showing metamorphosis of digestive system

SP Sieve plate P Pedicellaria C Calcareous spines F Sucker feet
M Mouth A Anus E Sight area To Touch area
Stomach and Ambulacral system – white

There is an interesting metamorphosis among the different sea urchins leading towards a bi-lateral symmetry. The basic pentagonal form of the Echinoderms is maintained, but the mouth (which is at the bottom) and the excretory orifice (which is at the top) alter their positions slightly. The whole creature becomes elongated a little, and tends to develop a bi-lateral symmetry. The sea urchin, as it were, through the elongated digestive system 'eats itself out of its radial symmetry'. In one species, the Heart Sea Urchin (Echinocardiumcordatum) a new feature appears, a kind of feeler formed from some of the prickles. These feelers are useful to the Heart Sea Urchin as it burrows in a sandy beach at low tide.

There is another remarkable creature, which is a near relative of the Starfish: this is the **Sea Cucumber**. In appearance it is like a very swollen, fat worm. Five stripes extend lengthwise along its body; these indicate the water-vessel system. Between the stripes the surface of the creature is bare. At one end there is a strange structure like branches of a tree; these are aquatic lungs.

The Sea Cucumber moves by creeping along. It is by no means attractive in appearance; its colouring is unpleasant, black and a strident red. Added to this it has a very objectionable habit of turning its stomach inside out. The Starfish, too, can eject its stomach when attacking shell fish such as oysters. It inserts the ejected stomach into the groove of the oyster and then begins to devour it. Sometimes several Starfish will attack one oyster at the same time. It is remarkable how flexible the stomachs of Starfish and Sea Cucumbers can be when they have been turned inside out! The strong digestive juices can dissolve even the shell of an oyster.

A first glance at a Sea Cucumber does not give us the impression that it is an Echinoderm, a relative of the Starfish. But a cross section through the creature reveals that its structure has a five-radial symmetry, and is basically like the Starfish.

We have described how the Sea Urchins of various kinds show a metamorphosis leading towards a bi-lateral symmetry. The Sea Cucumbers continue this tendency further. If they did not possess many characteristics of the Echinoderms, they could be considered Worms. But the worms are on the fringe of an entirely different animal group, formed quite differently from the

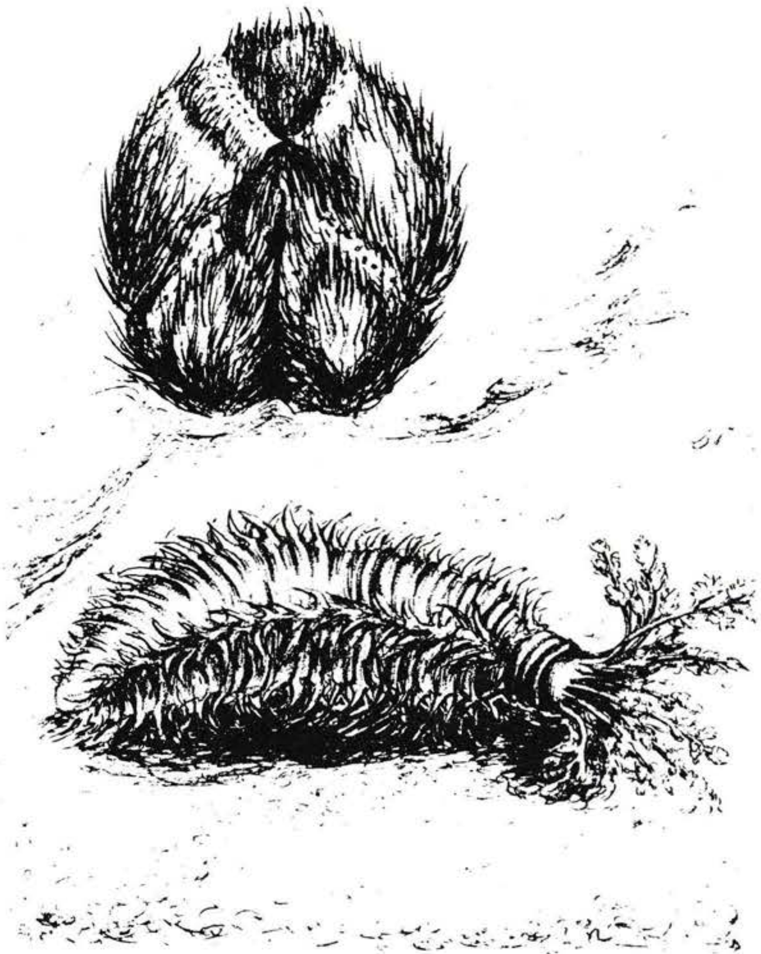

Fig.23 Heart Sea-Urchin (Echinocardium) Sea Cucumber (Aslia)

Echinoderms. The Starfish has certain qualities which lead to developments in other higher animal groups.

If we imagine a line of metamorphosis going in the opposite direction from that of Starfish – Sea Urchin – Sea Cucumber, we arrive at the Feather Star. This series leads from the Starfish through processes of more and more drying, and greater and greater hardening. It is interesting that in the early stages of their life the Feather Stars are often anchored to one position and do not move about, but as they grow older they become free swimming and float about. There is only one British species, the Rosy Feather Star, at present in existence. The Feather Stars can pass through further stages of metamorphosis until we arrive at the Sea Lilies.

At the present time, Sea Lilies are only found in very deep water. They are sometimes brought up by dredging from the ocean depths near Japan. They are very few in number, only pathetic representatives of what was in existence long ago. There used to be enormous marine forests of Sea Lilies. They were like Starfish with five-radial symmetry. Many species had ten arms and were attached to a stalk, and arranged with numerous individuals one above the other. The best known Sea Lily is Pentagrinas-liliformis, the type which can still be found in the seas around Japan.

An enormous number of Sea Lilies were in existence during former earth evolutions. They may now be seen as fossils in museums, where there are great blocks of stone consisting entirely of Sea Lilies; whole forests of Sea Lilies were fossilised in the far past, and turned into stone. Sometimes only the separate limbs are left, sometimes only the stalks.

The existence of Echinoderms can be traced back to the most distant age of earth evolution. Thousands of different varieties of Starfish are found as fossils, more than the numbers of species still in existence today. In the Rhineland many roofs are made from black slate, which is full of Starfish fossils. Other creatures were in existence at the same time as the Starfish, only since their bodies were softer, they were not preserved so well. The Starfish has a particularly strong form tendency. It is remarkable that Starfish of millions of years ago look exactly like Starfish which are living at the present time. A certain permanent form principle

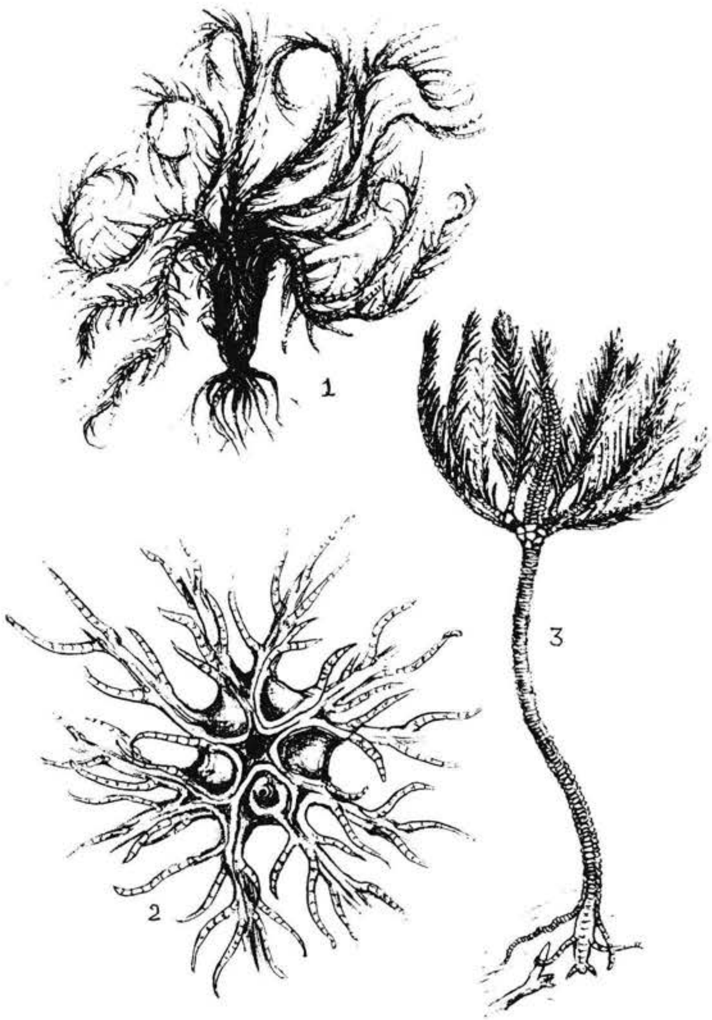

Fig.24 Rosy Feather Star
1. Swimming 2. Oral view

3. *Sea Lily*

is embodied in the Starfish. No other animal group has such an exact geometrical form. The mouth is pentagonal; the whole creature is permeated with the five-fold principle. In the Coelenterates the symmetry, where radial, has the numbers six or eight prevailing. In the Echinoderms, the number is always five or ten. No other animal group has incorporated such a geometrically exact form, in which the five-fold principle is so all-pervading, permeating the whole animal structure. The Sea Lilies are imbued with the same five-fold symmetry as all the other Echinoderms.

Sea Lilies are very brittle, as are many of the other Starfish species. They must be handled with care. But the powers of regeneration in the Echinoderms are very strong. Damaged parts are soon renewed.

Fig.25 Starfish – growing two new limbs

In the Echinoderms the two sexes are separate. Eggs and sperm are deposited in the sea water and then fertilisation takes place. The larva of the Sea Urchin is well known among zoologists because of certain unusual characteristics. It is mobile, free swimming, and it has an eyelash wreath. The mouth of the Sea Urchin has a five-fold geometrical form, the so-called 'Lantern of Aristotle'. It obviously incorporates the basic form of the Starfish.

Today the Sea Urchins, Sea Cucumbers and Starfish are all classified as separate families, included in the Phylum Echinodermata. We cannot imagine one type metamorphosing into another, yet this is what happened in ancient epochs. It is interesting that the present day Feather Star is sometimes firmly fixed to an anchorage; yet at other times it is mobile and free swimming. If the Starfish is metamorphosed in one direction it becomes a Sea Urchin, and then a Sea Cucumber. If it is transformed in another way it becomes the Feather Star and then the Sea Lily. If the Starfish is metamorphosed within itself, varying its proportions, then the Sun Star or the Serpent Starfish is produced. If we understand the basic structure of the Starfish, we can follow through the metamorphosis to all the other Echinoderm types. In former times when everything was softer and more pliable, animals could change their shape. In the Echinoderms, we have a type which shows great variety, but which maintains the five-fold geometrical principle.

Another interesting fact about this group is the limb structure. In spite of increasing hardening and penetration by lime compounds, the limbs of the Starfish retain their mobility. Many volumes could be written about the mobility of the Starfish. It has a remarkable limb structure from many points of view. The hardening process does not impair the flexibility of the Starfish. This creature is very strongly influenced by the water-vessel-system which it develops. This is a kind of primitive breathing-system with a watery foundation. What enables the Starfish to have such mobility is the introduction of AIR into its body; the Starfish not only eats and digests, it also BREATHES. From this arises the forming of a limb system and its capacity for movement. There is also the formation of a hollow part within the bodily structure, and the introduction of air into its body has a certain influence on the Starfish as an independent being, an individual creature.

If a Starfish is stranded the wrong way up, it rights itself. It bends its stiff arms by inflating the little tube feet in certain areas. These sucking tube feet absorb water and inflate, and can then exert a pull in certain directions. In this way the Starfish gradually bends its limbs and rights its position by turning over.

The Starfish and other Echinoderms live in marine forests in company with other flora and fauna in the lower groups of living beings. Many of these creatures have retrogressed and dropped out of the evolutionary process. There are many kinds of soft-bodied creatures, worm-like in shape. In these there is a bi-lateral symmetry. The Starfish are the last of the animals to have a radial symmetry, which belongs more truly to the plant kingdom. Many flowers have a radial symmetry. When an animal develops a digestive system and then 'eats itself into length', the radial symmetry which it may have possessed in the earlier stages of its life disappears; the form of the worm is created. If a worm is dissected, it is still possible to find five-radial symmetry in its structure, but this is only at a transitional stage in its development.

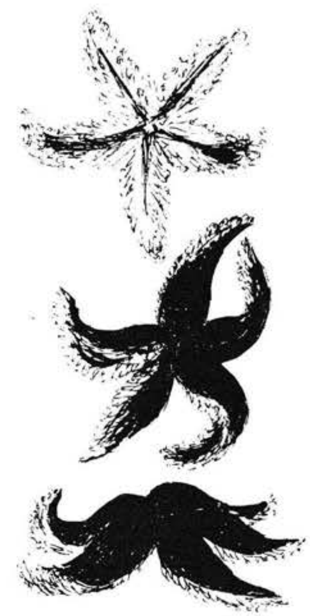

Fig.26 Starfish turning over

In conclusion, there is one more interesting fact. The Starfish is a curious creature. In some attitudes we can imagine the Starfish to be a somersaulting acrobat. If a human being stands in a certain position with feet astride and arms outstretched, his outline fits into a circle. This could not be done with a horse! A certain principle of radial symmetry is within man, which he can demonstrate by his own movement. The Starfish is the last among animals to maintain a five-fold symmetry. This radial symmetry disappears as various animal types 'eat into length', and develop an over-weighted digestive tract. We see how this has happened in the fish and the snake.

In man, the digestive system produces bi-lateral symmetry. But as the human being achieves upright posture, there is a further development. The five-radial symmetry comes back at a higher level.

In the Echinoderms, pure geometry is active in the animal kingdom for the last time. Starfish are like living geometrical thoughts, which are mobile and can alter their shape to a certain extent and can also move about. We can have nothing but admiration for such a combination: physical mobility in a body formed in accordance with strict geometrical laws. The Starfish is unique. It is an archetypal form of the animal kingdom.

The Starfish leads away from the more lowly 'plant-animal' to a definite animal type. We can observe what a striking and penetrating effect the absorption of air has in the Echinoderm animals. As air is breathed in, astral forces are drawn into the interior of the creature. The cavities within the body are not only digestive organs; they achieve mobility. With the development of the ambulacral (breathing – circulation – movement) system, the Starfish possesses qualities which neither the plants nor the hollow-bodied Coelenterate animals have. The Starfish is different, in that it is independent and individual, although its form has certain features in common with that of the Coelenterates.

The secret of the immense mobility of the Starfish is linked with the five-fold geometrical form. We can find examples of this five-fold radiating symmetry throughout the whole period of earth development. It can be traced in fossil remains of all the geological epochs, among the museum specimens on display.

We can find a link between the Starfish and Man. In the Starfish the five-radial symmetry is embodied physically; in Man it appears at a higher level. The Starfish is really a head, with a mouth in the centre and eyes on the periphery. Man has a head and four extremities; there is a spiritual link between these. The intelligence of the spiritual head form works with the dexterity of the extremities. The remarkable cleverness which the Starfish has in physical form appears on a higher level in the human being.

So far we have considered three of the lower animal groups:

> The **Protozoa**, of one cell only, such as the Amoeba, consisting of the basic substance of all living beings: protoplasm, from which all is created.
>
> The hollow **Coelenterates**, multicellular, with Two layers of tissue, an inside and outside. The principle of form creates the gastrula, an inside and outside, a necessity for all creatures.
>
> The **Echinoderms**, with THREE layers of tissue; these are more formed and have developed mobility from within, and a five-fold symmetry.

The creative principle works within all three groups.

Finally, we shall see how the laws of the creative processes, which are embodied in the lower groups of the animal kingdom, are working in the higher animals. We shall discover how the lower animal kingdom leads into matter, and then to the creative laws of the higher animal kingdom.

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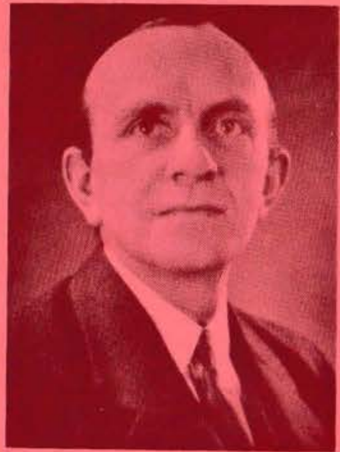

THE AUTHOR

EUGEN KOLISKO, one of Rudolf Steiner's most distinguished pupils, was educated at Vienna University as a doctor of medicine. He was also an authority on the Natural Sciences and History, and was a born teacher. As a lecturer in medicine, zoology, chemistry and history, he was much in demand, both in Europe and America. He died in London in 1939, at the age of 46.

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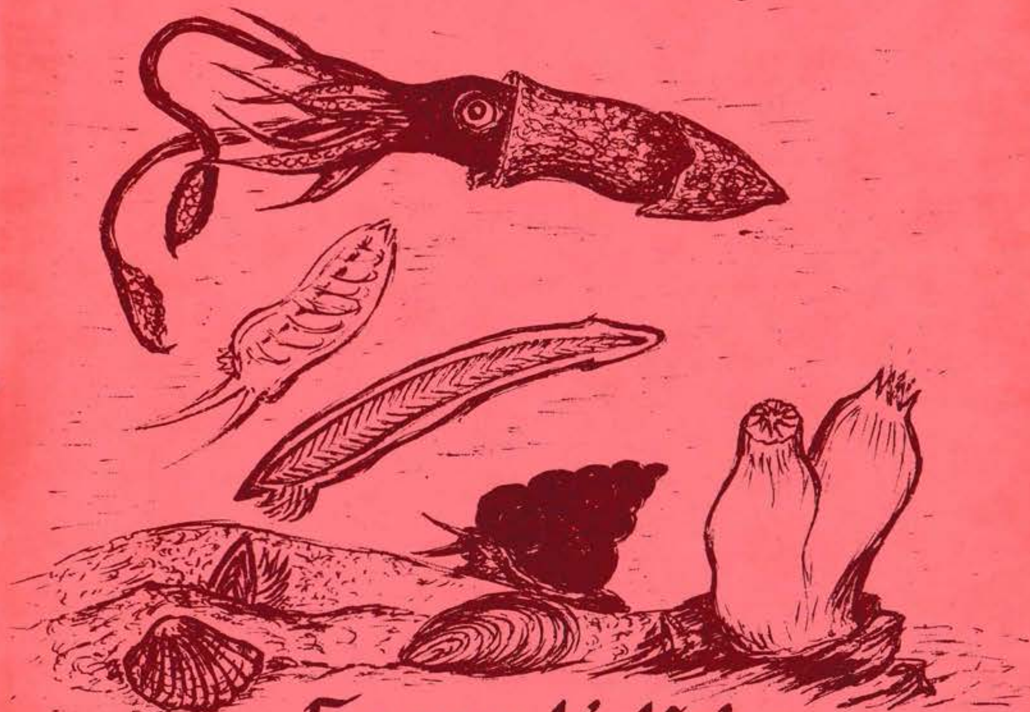
Zoology for Everybody

No. 6

Tunicates Molluscs



Eugen Kolisko

ZOOLOGY FOR EVERYBODY

A Series of Lectures

by

Eugen Kolisko
(M.D. Vienna)

8th and 9th Lectures
Tunicates and Molluscs

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Introductory Note

Dr. Kolisko intended to write a book on Zoology, incorporating the material contained in his series of lectures given in 1932. This was not accomplished in his brief life.

Soon after his death, Mrs. Kolisko published the first two lectures. In 1944 she suggested sketches which might illustrate Lectures 3 and 4, on the Mammals, which we published in 1979.

Last year, with the help of Gladys Knapp, we were able to publish a further volume on the Protozoa - Zoology for Everybody No.4.

We are again greatly in Gladys Knapp's debt for her continued efforts in translating and sketching the material for this booklet.

A.Clunies-Ross. Bournemouth, January 1981

List of Illustrations

ZOOLOGY FOR EVERYBODY
LECTURE 8

THE TUNICATES

In this course on Zoology, we first studied the warm-blooded animals: the birds and mammals. Then we turned our attention to the lower animals, working from below upwards, from the more simple types to the more complicated. Let us recall our studies so far. Of the lower animals we have considered three groups:

The **Protozoa** (single-celled creatures)

The **Coelenterates** (hollow animals)

The **Echinoderms** (spiny animals)

Briefly, the distinguishing characteristics of the Protozoa are: they are unicellular, i.e. consisting of one cell only. They are widespread over the earth, but live as separate individuals. They are living atoms, only forming a conglomerate mass when existing in numbers. At the same time we noted that Protozoa may be found within the bodies of living higher beings, both plant and animal. Among these unicellular creatures there is no clear demarcation between plant and animal qualities. It is important to remember that every living being passes through a unicellular stage, a kind of Protozoan state, at the beginning of its development.

The second group, the Coelenterates, are Metazoa, for they consist of more than one cell. They are in the form of a hollow sac, or bowl-shape. This is, in all essentials, a stomach, an organ of digestion. In the early stages of their development, the Coelenterates show a duality; they consist of two distinct layers, an outer and an inner. The former becomes the outer covering (ectoderm) and the inner layer (endoderm) becomes specialised for digestive processes. The Coelenterates have another kind of duality: they occur in two different forms, as polyps and as medusae. It is the polarity between the inner and the outer layers which is the decisive characteristic of the polyp type (such as Sea Anemones) and of the medusae type (such as the Jellyfishes). The Coelenterates are sometimes called 'plant-animals' or 'flower-animals'.

Thirdly, there are Echinoderms or prickly sea-creatures. These have a three-fold quality. Not only have they an outer layer and an inner digestive layer, but a third layer between these two, which forms a breathing-circulatory system. Often their structure is geometric . The Echinoderms (such as Starfish) are more mobile, more animal-like, and more independent than the Protozoa and Coelenterates.

Now we will consider another group of animals, of which very little is known. People rarely notice the creatures we will make the subject of our study today. It is only in the more comprehensive books on Zoology that there is any mention at all of these animals. Yet they are really very interesting. It is just this group of animals which points to the most extraordinarily interesting facts which are important for the study of the development and understanding of the whole animal kingdom.

These are the Tunicates, and we will consider this unusual group today. The Tunicates are exclusively marine creatures. They are soft-bodied and have not reached the stage of development of land animals. They have no bone structure or skeleton.

I must first of all describe some of them. This is especially necessary since they are so little known. Basically there are two different types: the immobile Sea Squirts, which are sedentary at the bottom of the sea, and the Salps which are mobile and free swimming.

The Sea Squirt is similar in appearance to a sponge, an ordinary bath sponge. It shows no movement, living permanently attached to rocks or seaweed. The most simple kind of Sea Squirt

Fig. 1 Sea Peach – a typical Tunicate
Lives on North Atlantic coasts of America, attached to rocks, a **Sea Squirt.**

looks like an upright bag, with two openings, the mouth and the atrium. The animal is completely enclosed in a tough covering, the 'tunic'. This tunic, the thickened outer layer of the body wall, is made of cellulose. This is a substance not usually found in animals, but which gives toughness and support to some plant structures. Animals which are static, and which have given up free movement are usually degenerate types. The adult Tunicate is degenerate, for in its larval state it is free-swimming. The Sea Squirts are filter-feeders. This means that they derive their nourishment from the content of the sea water which streams through them. Some Sea Squirts live as single individuals. Others cluster together in groups, uniting into colonies, as do some of the Polyps. Some of you may know these animals if you have travelled in Italy. There they are sold in the markets as 'frutti di mare', sea-fruit. They are offered for sale with Cuttlefish, and are eaten like oysters.

The interior of the Sea Squirt is mostly filled with a large pharynx, perforated by many slits, called pharyngeal slits. Cilia around the slits create a current which draws water into the mouth, through the slits, and out through the atrium. If the animal is disturbed, the hollow body contracts and the water within it is

Fig.2 Dendrosa grossularia
Small red Sea Squirts growing in groups on rocks near low water mark, around coasts of British Isles. (*Natural size*)

poured out in two jets, hence the name 'Sea Squirt'. The pharynx is an organ which serves not only for breathing, but at the same time acts as a mouth and stomach. There is also the real stomach and a kind of intestine, at the end of which there is an opening, the anus. There is a blood vessel system which is a tube-like heart, surrounded by blood vessels. The heart has a remarkable faculty, of contracting first on one side and then on the other for 50 or 60 beats. It is as if the arteries and veins exchange their functions. The blood circulation does not go in one direction continuously, but vacillates from one side to the other, reversing the direction of the blood flow.

The Sea Squirt is hermaphrodite; it fructifies itself. Eggs are laid or sometimes the young are born alive, already developed within the animal.

Thus the Sea Squirt has a complicated anatomy, with systems for breathing and digestion. It also has blood vessels with a heart, and possesses a nerve-ganglion which sends a nerve thread through the whole animal.

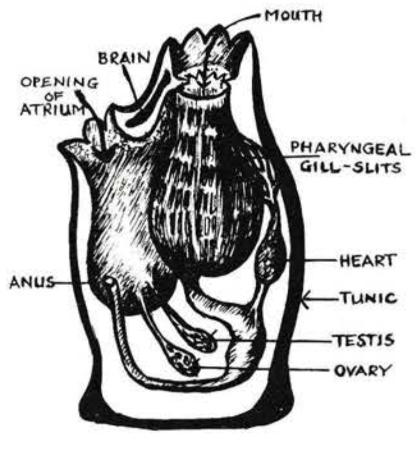

Fig.3 Longitudinal Section through a Sea Squirt
(diagrammatic)

Related to the Sea Squirts are the Salps. These are more delicate and more beautiful than the Sea Squirts. The Salps are present in vast numbers, in shallow and in deep sea waters, sometimes in such enormous quantities that they form a huge mass of animal pulp.

Salps were first discovered by an unlikely personality, the poet Albert Chamisso. He wrote a description of his voyage round the world, giving many natural-scientific details. He wrote about the Salps. It was Albert Chamisso who first discovered a remarkable fact about these creatures, that is 'the alternation of generations'. There are two methods of propagation in the Salps, one sexual and the other asexual. Chamisso says that each of the Salps only resembles its Grandmother; only alternate generations have the same form. The Salps are translucent, although they are covered with tough 'tunics'. A comparison may be made between the sedentary Sea Squirts and the mobile Salps, just as the sedentary polyps may be compared with the free-swimming medusae. But the difference is more pronounced in the Tunicates than is the case with the Coelenterates.

Single Salps are produced sexually, but there is also asexual propagation, by 'vegetative budding'. Amoeba-like 'buds' are released from little barrel-shaped cases. All lowly creatures can replace damaged parts by vegetative budding. In the Salps the Amoeba-like 'buds', produced asexually, may form a whole colony, the younger ones developing over the older ones, forming

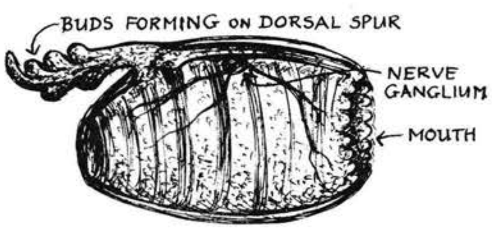

Fig.4 Doliolum – a free swimming Tunicate
Reproducing asexually by budding.

an encrusting mass over rock surfaces or seaweeds. This kind of budding may lead to an enormous family.

But the 'alternation of generations' by sexual and asexual propagation is by no means the most important fact about the Salps. The most remarkable and interesting fact consists in the development of these creatures. It is not so much the structure of the adult Sea Squirts and Salps that is so extremely interesting. Every living creature starts life as a single cell, a protozoan type of stage to begin with. Both the Sea Squirts and the Salps pass through a gastrulation stage as they develop, and proceed to a rather complicated anatomy during their embryonic stages.

But the adult Sea Squirts and the adult Salps become degenerate. For a long time the Sea Squirt is a free-swimming larva. Its shape is reminiscent of a tadpole. It has a long tail which contains muscles, a well-developed NOTOCHORD and a DORSAL TUBULAR NERVE CHORD. Its trunk has a pharynx with slits or gills. But finally the larva settles down on a rock, loses its tail containing the Notochord and the Nerve chord. The adult Sea Squirt is a degenerate form in comparison with the embryo (larva). It has no trace of a Notochord and its nervous system is represented only by a ganglion in the dorsal region of the body, between the two openings.

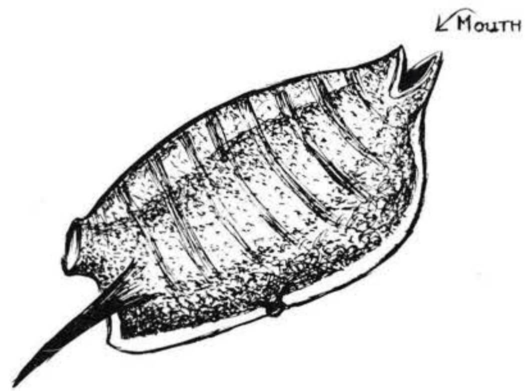

Fig.5 Salp – a free swimming Tunicate

The Salps also pass through a larval stage with a tail. The larva has a stomach, and a long tail. Inside this tail is a harder formation, like a kind of skeleton, and a sort of spinal marrow, the back chord or Chorda dorsalis (spinal cord). Above there is an organ which is sensitive to light, a kind of eye.

The Chorda dorsalis is a formation which is always present in the embryonic structure of the higher animals, the Vertebrates. In the centre of the Vertebrae there is always a softer part which goes through the whole body. In the embryo this softer part is the back chord (spinal cord) before any bone has formed. The bone substance gathers around this back cord during further development. This 'Chorda dorsalis' is found in the free-swimming larvae of Sea Squirts and Salps. At this embryonic stage the Sea Squirts and Salps are passing through a stage which is only found otherwise in the embryonic stage of the higher Vertebrate animals.

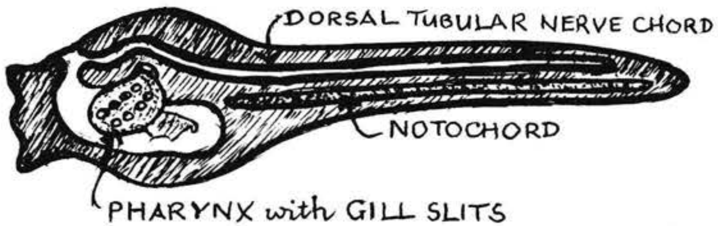

Fig.6 Enlarged Larva of Sea Squirt
Free swimmimg.

Thus the Sea Squirts and Salps pass through a larval stage with a tail. Then they cast off this tail, together with the Chorda dorsalis, the segmentally formed muscles and also the eye and nerve ganglion and the whole dorsal part. Only the ventral (stomach) side of the embryo is retained, which then forms the adult Sea Squirt or Salp. The adult animals had a much more perfect anatomy during embryonic development than in their finished adult forms. In the adult stage both the Sea Squirts and the Salps show processes of degeneration.

The most lowly animal which we may call a fish is the LANCELET. It has no vertebral column, but a chorda dorsalis, such as is found in the larvae of the Sea Squirts. The form of the Lancelet is not very different from that of the embryonic stage through which all the Vertebrates pass during their development. The Lancelet is very closely related to the early forms of the Salps. It has been discovered that some species among the Salps keep the larval stage all their lives, and therefore come very close to the Lancelet.

The Lancelet has been known much longer than the Salps. It is translucent, more or less colourless, perhaps with a slightly reddish tinge. It looks something like a small snail.

The Lancelet was first discovered in 1774 by Pallas, who thought it was a snail of some kind. Later it was discovered that the Lancelet had a Chorda dorsalis and therefore was not a snail. Microscopic investigation shows that the Lancelet looks like a fish without a head. It is given the official name **Amphioxus Lanceolatus**, that is 'pointed at both ends'.

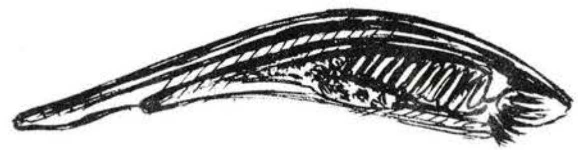

Fig.7 Lancelet (actual size, drawn from preserved specimen)
Distributed all over world on sandy shores, in which it burrows when not swimming.

This animal has played an important part in discussions about the development of the animals in the course of evolution.

The Lancelet is widely distributed in marine waters and may be found in seas around Europe, in both the Mediterranean Seas and Scandinavian waters. Its development has been studied in connection with the development of the Vertebrates (animals with backbones). It is really the most lowly developed of the Vertebrates. For this reason Ernst Haeckel was very interested in it. Many of his theories of evolutionary development are based upon his studies of the Lancelet, which he calls 'the most noble ancestor of Man', because it forms a strange bridge between the lower animals (Invertebrates) and the higher animals (Vertebrates).

The embryo of the higher animals passes through a stage in which it is like the Lancelet. This is the most simple structure imaginable. Below is the ventral system (the intestinal system). Above is the dorsal system (this consists of nerves), with a kind of spinal marrow; and the back (spinal) cord. This is really the fundamental plan of the anatomy which we find in the trunk of the human being. The nerve system is at the back with the skeleton built around the spinal cord. The skeleton of the Vertebrates is crystallised around the spinal cord.

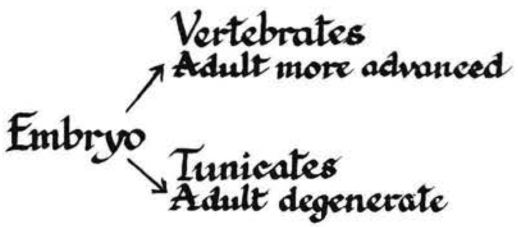

Fig.8 Diagram of development of Tunicates

If we insert a thread into a vessel containing a solution of salt, then the salt crystallises around the thread. It is in a similar way that the backbone and spinal cord come into being in the Vertebrates during the embryonic development by the spinal marrow, and around them both the bone-system is formed. It is interesting to discover where the spinal cord appears for the first time. The spinal cord is characteristic for the Vertebrates, the animals with backbones. There is a great gap between the Vertebrates and the soft-bodied animals, the Invertebrates. The Lancelet bridges the gap. It is strange that the nearest relatives of the Lancelet are not among the fishes, but among the Sea Squirts. So we may describe the Lancelet by saying that it is like a freely-swimming embryo of the higher animals: the Vertebrates. The same description is valid for the early larval form of the Salps.

Normally the embryo of a Vertebrate develops upwards to a higher form. In both the Lancelet and the Salps the normal form of the adult animal is less perfect than that of the embryonic form. The development is downwards; there is degeneration. In evolution an upward development in one direction is always balanced by a fall in perfection in another direction.

This is most interesting and leads us into a study of embryology; whilst studying the Salps we cannot avoid being drawn into a consideration of embryology. The development from the egg cell, throughout the embryonic stages of the Salps, is similar to that of the higher animals, the Vertebrates. If the Lancelet is included as a member of the group of the Tunicata, as it is in some systems of classification,* then the similarity of the embryonic forms with those of the Vertebrates is still more striking. The form of the Lancelet in its early stages is more like that of the fish, and also more like that of a stage of development in the human embryo, than is the case with other Tunicate creatures.

Here I would like to draw your attention to a strange fact: in the Tunicates the heart pulsates to two different sides, first one and then the other.

If we make a detailed study of the Earthworm, we find that it has a blood-vessel system which pulsates like a heart. This blood system is dorsal; that is it lies at the back, and drives the blood to the ventral (or stomach) side. The fish has the opposite arrangement. Its heart is on the ventral (stomach) side and the blood flows towards the back. In Man, also, the great artery is in the front of the body, and the blood flows towards the back. This direction of the movement of the blood is connected with the position of the nervous system.

The Earthworm has no backbone (it is an Invertebrate), and its nervous system is on the ventral (stomach) side. This arrangement is changed in the case of the fish and all other backboned (Vertebrate) animals. The point comes when they begin to transform from the soft-bodied creature, during the later stages of embryonal development, and make the first steps towards developing a spinal cord and backbone. At this point in their embryonal process we notice the remarkable fact that the blood-system cannot decide which way the blood is to flow, and therefore oscillates to and fro, first flowing in one direction for a certain time, and then in the opposite direction for another period. In the Lancelet the pulsations move round ring-wise, thus in a circular form. In this case the direction of the blood flow has

***Tunicata** – Urochorda – Sea Squirts Salps
Cephalochorda – Lancelets

already been decided. Not so in the Salps, in which the circulation moves in one direction for a number of pulsations, and then reverses its flow. Thus it continues moving to and fro, first in one direction and then the other.

It is always difficult to understand how such a complicated being as an animal can develop from a single cell. First there is the spherical egg-cell. Then a gastrula formation or sac-like form develops. The Salps show this very clearly. So, too, can the gastrula form be seen among the Coelenterates. Why is it that it is in these creatures that this sac-like form can be seen so clearly? The fact which is interesting and which must be noticed is not the shape of the adult animal, but the form during development of the embryo. The Salps are abnormal because the forms during embryonal development are more perfect than those of the adult creature. The embryonal forms prove to be archetypal stages of the higher animal types. The Salps demonstrate the remarkable fact that some parts of the animal are held back at a very early stage of development. In this group the embryonic development has greater significance than the adult form. The Salps show embryonic forms in a relatively undeveloped stage. With the Sea Squirts, Salps and Lancelet we see animals which allow us to look into the whole process of the evolution of the animal kingdom.

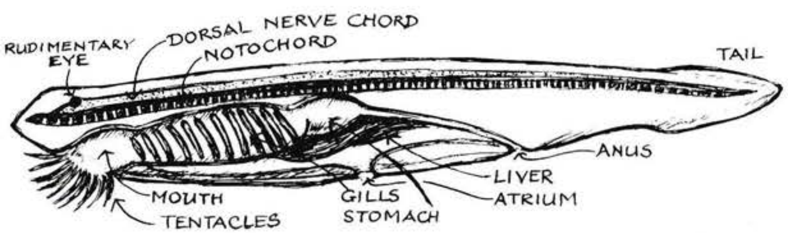

Fig.9 Diagram of Lancelet (*Amphioxus Lanceolatus*)

Haeckel emphasised the importance of the study of Amphioxus lanceolatus (the official name for the Lancelet, meaning 'pointed at both ends') and the Salps and Sea Squirts. Here is an animal group which produces the same form in the embryo as do all the higher animals and the human being. It indicates that these creatures are the remains of a process of

evolution closely allied to that of the human being, only they have fallen back in their evolution as animals into quite an early stage. Such an example indicates that all phases of animal evolution express stages of human evolution, but they also lead away from it through falling away into comparative decadence. In the Protozoa the system of the cell falls out as a type from the advancing evolution. In the Coelenterata the digestive system does. In the Echinodermata the circulatory system (fed from the external world), and in the Tunicata the later part of the embryonic process falls out from the advancing evolution.

In the Protozoa, Coelenterata and Echinodermata we have the successive evolution of the three main layers of tissue. In the Tunicata these three layers are combined to give the archetype of all embryological evolution. In this animal group is the secret of the animal becoming its individual self. This is why Ernst Haeckel was so occupied with the Tunicates in his study of the evolution of the animal kingdom. In studying this development we are led to processes of ascending and descending, not to a direct linear ascent.

The Tunicates have many peculiar features. They alone, among the animals, secrete coats of 'tunicin', a substance almost identical with cellulose, which is normally found only in the plant kingdom. Here again, rather deeply concealed, is a kind of archetypal picture of embryonic evolution. In the very primitive unicellular creatures there is often no clear distinction between plant and animal characteristics. There are 'plant-animals' and 'animal-plants'. The Tunicates have preserved as it were, a memory of this characteristic of the earliest forms of life.

Why do we not perceive a clear picture of embryonic evolution in the higher animals? It is because they have moved far away from the embryonic archetypal picture. They have not retained within themselves the embryonic evolution. But there is one group of animals which has this within itself. The creatures within the Phylum Tunicata are nothing else but pictures of the development of the coming into existence, of the embryo. The Lancelet resembles very much the early growth forms of the Sea Squirts and the Salps. The Lancelet may be considered as a Salp or a Sea Squirt which has remained for its whole life in the embryonic form.

These creatures allow us to look through to the development of the anatomy of the Vertebrates. They have essentially the rudiments of all the organic systems which are present in the higher animals. The Salps and the Lancelet are nothing else but embryonic formations freely swimming in the sea. They cannot be compared with any other group of animals. In view of this it is justified to have made this group, so rarely studied, the subject of our studies today.

—★—

ZOOLOGY FOR EVERYBODY
LECTURE 9

THE MOLLUSCS

The subject of this lecture is the group of soft-bodied creatures called Molluscs. In the last lecture we considered another group of soft-bodied creatures, which are not nearly so well known as the Molluscs: the Tunicates. We discovered that the Salps and other Tunicates are most interesting in the very early stages of their development, and are degenerate in the adult form. They are like embryonic creatures freely swimming in the sea. They point towards the evolution of the higher animals.

Quite different are the Molluscs. Though soft-bodied, as their name indicates, they have hard cases and shells. The remains of Mollusc shells have played an important part in the forming of certain rocks of the earth. They are very numerous, and a remarkable characteristic is that their bodies are soft but their shells are of a very hard substance: **lime**. It is in that region, between the soft body and the hard calcareous shell, that the life of the Mollusc is lived.

The structure and forms of the Molluscs are quite different from those of all the creatures we have studied so far: the Protozoa, Coelenterata and the Echinodermata. We were impressed by the wonderful geometrical forms found in the Starfishes, and sometimes in the Protozoa. But we only need to glance at a collection of shells of the Molluscs, and we shall see that the basic form is entirely different; round and spiral shapes predominate.

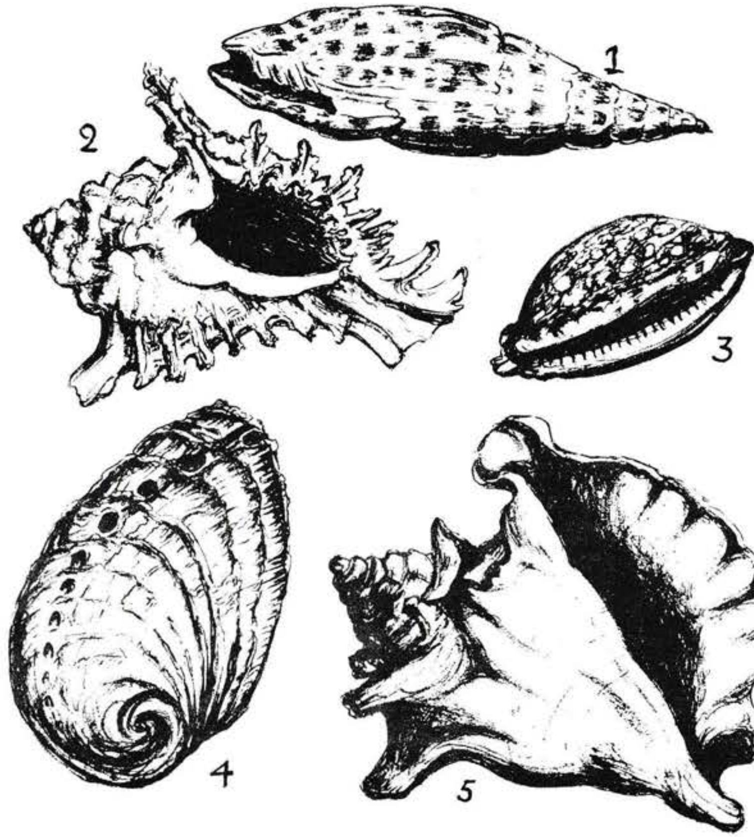

Fig.10 Shells of Gastropoda

1. Bishops Mitre (*Ceylon and Philippines*) 2. Phyllonotus (*Pacific*) 3. Cypraea arabica(*Eastern seas*) 4. Abalone (*California*) 5. Conch (*West Indies*)

When we begin to investigate the lives of the Molluscs, we find that it is obvious that there are three main types:

Cuttle-fishes (Cephalopoda)

Mussels (Acephala)

Snails (Gastropoda)

The Cephalopoda (literally 'head-foot') are quite different from the Mussels and Snails. The 'head-footers' are the Cuttle-fish . The Acephala ('head-less'), so called because their heads are not obvious, are the Mussels.

The Gastropoda (literally 'stomach-foot') are the Snails. These glide along on their stomachs.

These three groups have certain characteristics in common, but the three different types have clear demarcations in bodily structure. All have a soft body which contains a large amount of protein. All have a hard shell which has a decided form and contains lime.

Let us consider the three types separately in a little more detail. We will begin with the Cephalopods, the Cuttle-fish. These are strange creatures, quite different in appearance from all other animals. They are marine creatures, found only in seas and oceans. The Molluscs are mainly marine animals, but the other two groups, the Shell-fish and the Snails, though found chiefly in salt waters, include a few species which are exceptions, inhabiting fresh water or damp land.

The Sepia Cuttle-fish is an example of a Cephalopod which is fairly well known: This is the creature from which sepia dye is obtained. Like other Cuttle-fish it has a remarkable form. The most obvious features are the tentacles, two long and eight shorter. These surround the mouth, and they are covered with sucker-warts, which enable the creature to seize and cling to its prey. The tentacles also enable the Cuttle-fish to move rapidly through water.

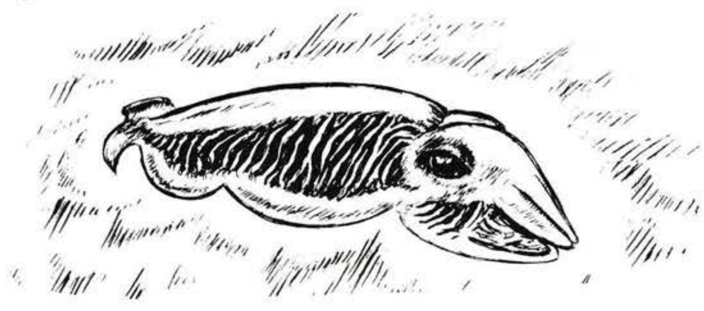

Fig.11 Sepia Cuttlefish

The Shell is a calcareous plate, embedded in the fleshy mantle, and is the Cuttlebone given to cage birds.

Most striking, too are the remarkable eyes, which are highly developed in structure; and which are very prominent. These eyes are large in comparison with the size of the rest of the body. Sometimes the eyes are so prominent that one can scarcely bear to look at them. It seems quite incongruous to find in a soft-bodied creature, such developed eyes, which may only be compared with the eyes of the most highly developed animals.

The inner organs of the Cuttle-fish are enclosed in a sac, at one end of which is the mouth, and at the other end a sort of funnel-like projection. From this funnel the water, which has been taken in through the mouth is released, and this arrangement also helps the movement of the Cuttle-fish . Among the organs within the sac-like body there is a heart and a sort of blood-circulation, one kidney and a primitive liver. Around the mouth there is a salivary gland. If the Sepia Cuttle-fish is frightened or attacked this salivary gland squirts out the so-called sepia ink, which so darkens the surrounding water that it provides a concealing cover for the creature.

Lorenz Oken said: "The Cuttle-fish is a swimming tongue and eye, joined together by a salivary gland". Indeed the Cuttle-fish may be described thus; it is a mouth, with lips, tongue and protruding trunk. It is, as it were, just a head, into which bodily organs have been included, within a sac-like formation.

The Cuttle-fish moves rapidly, usually in the opposite direction from that of most other creatures, that is backwards. But it can travel either backwards or forwards. It looks somewhat like a swimming elephant head. The tentacles are arranged around the mouth in a star-like formation, but they are usually folded in such a way that the whole creature appears to be shaped like an elephant head. We cannot say that the Cuttle-fish has a body; it looks more like an elongated head.

We do not get the right impression of the true colour of a Cuttle-fish if we only look at a dead specimen. Brehm, in his work on *Animal Life*, describes the colour phenomena of the Cuttle-fish. We can observe the whole range of the rainbow colours in such a creature. The colours are variable over the whole body, and change according to its moods. If the Cuttle-fish is excited or alarmed the colours move towards the eyes. When the creature becomes calm again, the colours spread over the whole body.

This colour phenomenon in the Cuttle-fish resembles that of the Chameleon, which, however belongs to a much more highly developed animal group.

The Sepia Cuttle-fish has, within the skin of its back a strange form, the so-called 'Cuttle-bone'. This Cuttle-bone consists of lime and is a part of the back; it is an internal shell. It is all that remains of a much more complicated shell structure which the Cuttle-fish possessed long ages ago. During the evolution of the earth the Cuttle-fish has passed through changes in its development.

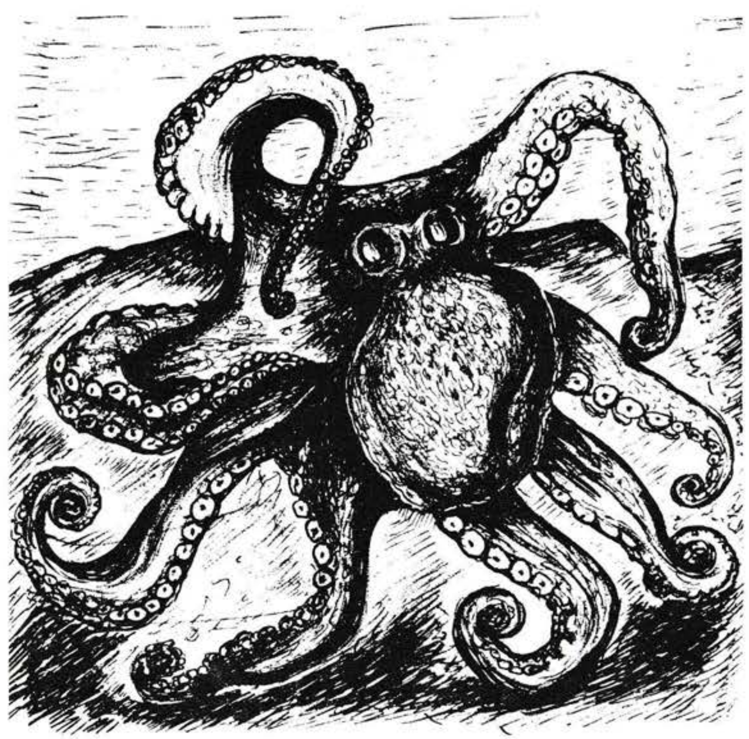

Fig.12 Common Octopus

All the Cephalopods are predatory creatures. The Sepia Cuttle-fish has ten tentacles, and the creatures in this group are smaller in size than the Cephalopods with eight tentacles, among which is the Octopus. Many of this group are very large. For a long while stories about huge Cuttle-fish were considered to be exaggerated tales by over-imaginative travellers. But it has been proved that such creatures exist. In 1861 fishermen reported Cuttle-fish with tentacles twelve to fourteen metres long. Since then, from time to time, some have been discovered with bodies five or six metres long and tentacles some fifteen or sixteen metres in length, making the total length of the creatures over twenty metres. It is quite dangerous to attempt to catch such an Octopus. The harpoon sinks into the soft flesh, but the fish does not seem to feel it at all, because its body seems to be of a very tough substance, somewhat rubber-like in texture. The huge tentacles with the sucker-wart discs can be very dangerous to fishermen.

Fig. 13 Octopus Eggs (*natural size*) and Young Octopus (*x4 natural size*).

Aristotle spoke quite a lot about the Cuttle-fish. Many of the facts he expressed were later proved to be true. He stated that there were two separate sexes among the Cuttle-fish. Certain of the males develop a sort of tentacle which penetrates the organism of a female. This tentacle becomes detached from the male and lives within the female for some time. Only after a while does penetration and propagation take place. This has been shown to be the case with the Cuttle-fish.

There are many interesting facts about the Molluscs which show that they are creatures with a very long history. Through the various shell formations we can trace their connections with former epochs.

We have just described the Sepia Cuttle-fish, which has only the Cuttle-bone, a remainder of the shell. Now we will consider another Cuttle-fish, the Nautilus or Pearl-boat, which is found in the Indian Ocean at the present time. This has a beautiful pearl-coloured shell which emerges from the back of the fish just at the place in which the Cuttle-bone is found in the other Cuttle-fishes. The shells of Molluscs grow at irregular intervals. In certain seasons the shells increase in size on the body side, and then at

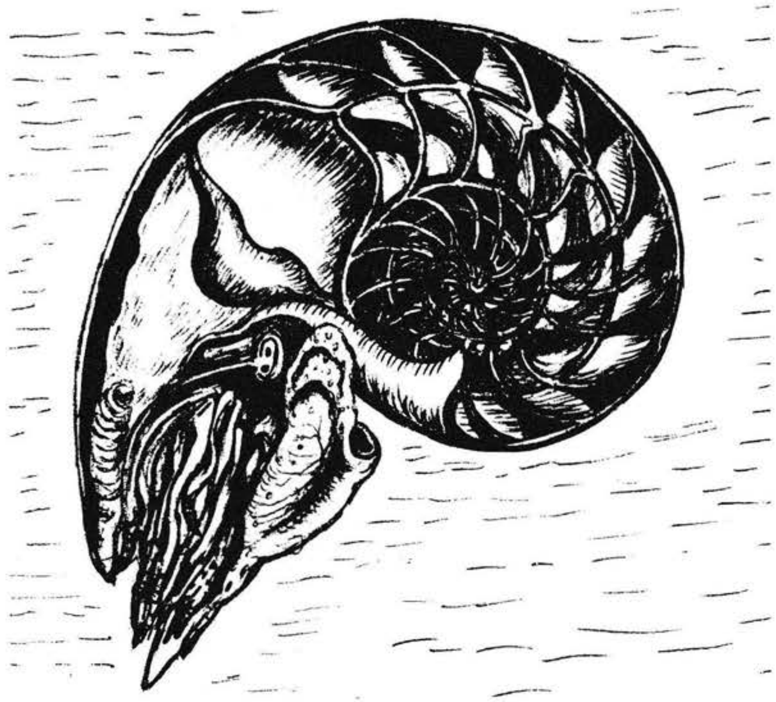

Fig 14. Nautilus (*Pearl Boat*) half natural size.

intervals there is growth to form partition walls. The Nautilus fish does not live within the shell; it is only linked with the air chambers within the shell. Air is secreted within the back of the shell, which grows in the front as it increases in size. The air supply of the Nautilus is very important; it enables the creature to live in very deep water. The shell acts like an air-float, and the air content can be regulated according to the pressure of the water.

There is a similar creature to the Nautilus, called the Paper-boat, which is smaller and much more delicately made with a paper-thin shell. The male of this species is very small and has no shell at all; it looks like a single tentacle of a Cuttle-fish. There are similar different creatures in which only the females have shells. This seems to point to the fact that in former epochs the methods of propagation were different.

The Pearl-boat and the Paper-boat have so-called relatives, which inhabited the earth long ago, but have become extinct. These are the Ammonites. Numerous varieties of Ammonite shells are found in the limestone rock formations of the present time. Ammonite shells are formed like the Pearl-boat. We have to imagine a soft-bodied creature like a Cuttle-fish within the Ammonite.

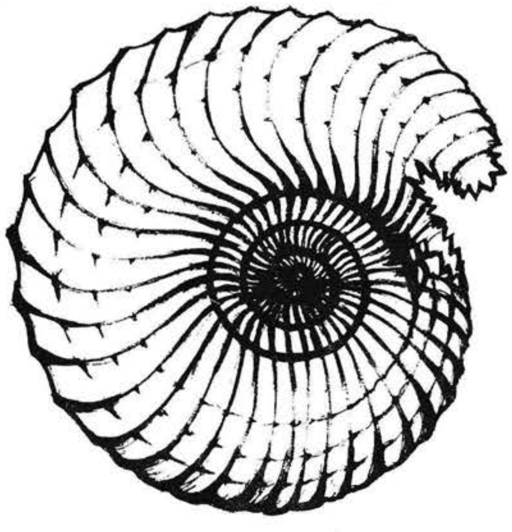

Fig.15 Fossil Ammonite.

The Ammonites are the delight of the Palaeontologists. The spiral form of the Ammonites is beautiful; the regularity of the structure is significant. There is an immense number of different kinds, varying from tiny specimens to others several feet in diameter. These are the 'guide-fossils' used by geologists to classify the different kinds of rock. Without the Molluscs, classification of certain rock formations would be very difficult. Each kind of Mollusc is characteristic for one layer of rock. Happily there is always a guide fossil for each layer of rock, and these are practically all the shells of various types of Molluscs. If there had been no soft-bodied creatures which lived long ago and left their shells behind as fossils, the non-organic rock formations would be difficult to classify. The Ammonites are the remains of a very ancient group of animals, which passed through various developments. They were in existence for a very long while and then suddenly disappeared at the time of the Saurians.

There are some areas where the rocks are made almost entirely of the remains of Ammonites. This is not always immediately obvious for the shells have become disintegrated during the vast periods of time and exist now as various types of limestone rock. The Jura and Wurttemberg areas consist mainly of Ammonites. Now these ammonite creatures are extinct, but we can see what they were like from the Pearl-boat and Paper-boat Cuttle-fishes still found in the Indian Ocean of the present time.

The Indian Ocean and its surroundings still contain many reminders of the so-called *Lemurian Continent*, which according to Geology, was in existence during the Jurassic period, a part of the Mesozoic Epoch. The Pearl-boat and the Paper-boat Cuttle-fishes belong to this area and to this time. We look into very remote ages of our earth when studying the Cuttle-fishes. These creatures have the tendency to develop their shells towards the backs of their bodies, and to use them as air-floats rather than dwelling places, gradually abandoning them except for the 'cuttle-bone'.

Otherwise the Cuttle-fishes have changed little throughout their long history. The Pearl-boat Cuttle-fish shows the connection with the extinct Ammonites, relatives of the Cuttle-fish.

The spiral form of the Ammonite shell appears again and again. The horns of some sheep resemble Ammonite spirals; the lime-shell formation of the horns develops backwards. So too do the giant structures of the Ammonites which once lived in the depths of the oceans. The spiral structures are sometimes called Ammonitehorns.

The eye of the Cuttle-fish looks intelligent but not kindly or well-intentioned! It is connected with a primitive brain, but it is only a *sight brain.* Aristotle commented that the Cuttle-fish is more vicious than any other animal. We can only confirm this fact. If we observe creatures of the deep oceans, such as the Octopus for example, we must admit that this Cuttle-fish appears to be intelligent but of a weird and uncanny character.

Besides the Ammonites there were other Cuttle-fish, now extinct, which were numerous in the Jurassic period. We find numerous fossils of the Belemnites in limestone rock. These were Cuttle-fishes with a straight shell and form. The true Belemnites are extinct, but some similar types can still be found here and there in the Indian Ocean. The fossil remains of the Belemnites are sometimes called 'Devils-fingers' or 'Thunderbolts'. Sometimes they are so numerous that they form a whole rock formation.

So much for the Cephalopod group. Let us now consider the Acephala or 'headless' creatures, so called because the head is invisible. These are the shell fish, the Mussels.

The Mussel has a remarkable form. We can best see the characteristics of the Acephala by observing the Common Pond Mussel. It has two shells and the so-called foot which can be put out of the shell, as it were.

The Mussels are the most phlegmatic of all the animals. They scarcely do anything at all. They are nearly always quite static, and only very rarely do they open their shells a little. Only very occasionally do they move a short distance. their most important occupation is breathing. Inside the shell is something which looks like a book with many pages; these are the gills. The body of the Mussel fills the whole space within the shell, and consists of a protein-containing substance enclosed within the sac, which adjoins the inner shell. Besides the well-formed gills there is a primitive blood circulation, a small gullet, one foot made out of a slimy substance which contains a short bowel. There is not much else; no nerve system, no sense organs. Everything connected

with the breathing is wonderfully developed. Apart from this, there is a muscle which holds the two shells together; the muscle acts as a lock and keeps the shell closed very firmly. Anyone who has tried to open a mussel knows how difficult a task it is.

Shell fish are widely distributed over the whole earth. Some live in fresh water, others in seas and oceans. There are many different kinds. One characteristic is common to them all: there is

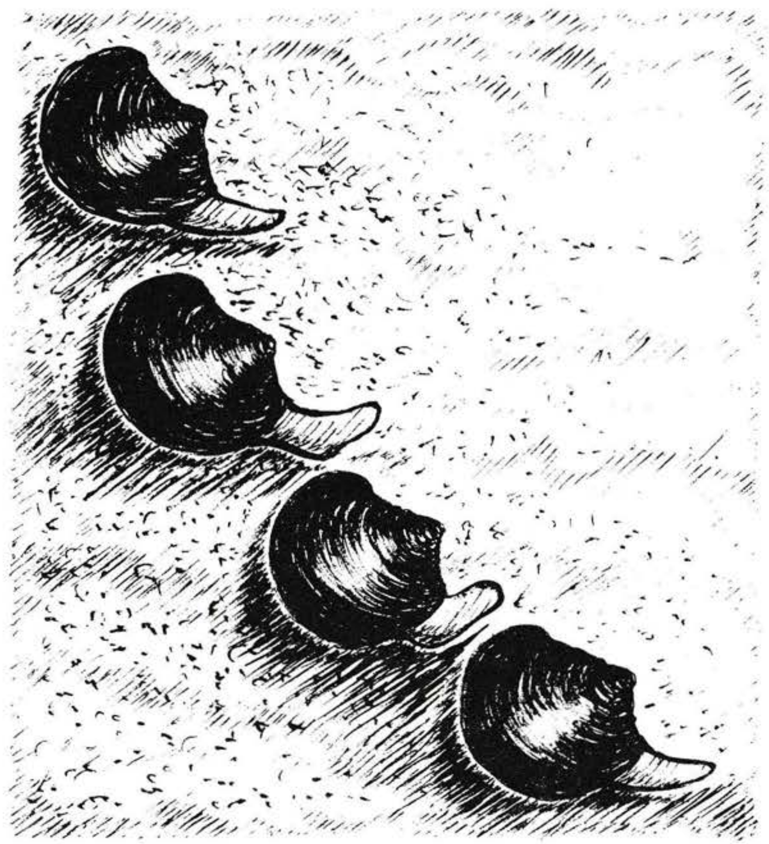

Fig. 16 Four successive positions of a Clam as it creeps over sand.

always the soft body of the creature consisting mainly of protein and the contrasting hard shell formed of lime. A certain balance is maintained between the two contrasting principles: the formation of protein and the formation of lime. The two meet where the body mantle contacts the inside of the shell. On one side is the organic, the protein substance which is alive. On the other side is the inorganic, the mineral lime. A kind of balance takes place between the two contrasting principles, where the living protein meets the mineral lime; the result is the production of the **Mother-of-pearl** lining of the shell.

All shell-fish have the capacity to produce Mother-of-pearl. Some varieties produce more than others, especially the River Mussel and the Sea Mussel which provide pearls. In these two types any foreign body which is found inside the shell is clothed with mother-of-pearl. The Mollusc seems to be waiting to form drops around some centre; layer after layer of mother-of-pearl is wrapped around the intruding object. Pearls can be formed naturally or artificially. In South-east Asia a tiny figure of Buddha is sometimes inserted into mussel shells, and after three years it is covered with pearl substance. Natural pearls are only found very occasionally.

If we investigate the structure of a pearl we find that it consists of many layers. At the centre there is organic substance. This organic substance is surrounded by concentric layers, and on the outside is the mineral which reflects the light and is iridescent. A precious stone in a drop-like formation is produced by an animal. The result is something resembling a quicksilver drop. The pearl is spherical in shape but has the character of a precious stone. Such a jewel could only arise in the animal kingdom.

This is very interesting from the point of view of a chemistry* which has a spiritual-scientific orientation. The scientists of former times would have described the phenomenon of the pearl as a 'mercurial process', in which a balance is produced between a 'salt'(mineral-inorganic) principle and a 'sulphurous'(combustible-organic) principle. In the mussel these two contrasting states meet on the border between the lime shell and the soft albuminous body. In mother-of-pearl and the pearl the two are in balance, in harmony.

*See Elementary Chemistry by Eugen Kolisko.

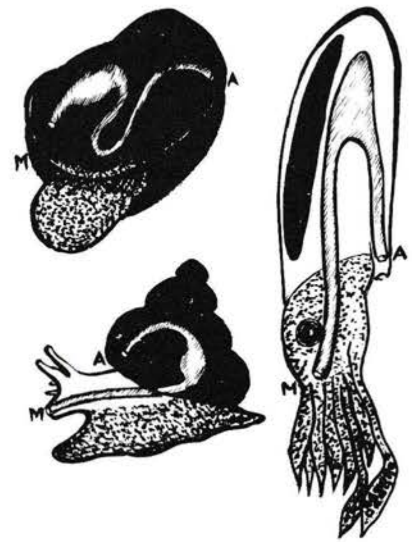

Fig.17 Molluscs (*three types*) M – mouth A – anus.
Showing relative positions of shell (*black*) – stomach (*shaded*) – foot (*dotted*).

In other Molluscs, the Cuttle-fish (Cephalopods) and the Snails (Gastropods) the mother-of-pearl does not arise. The Cuttle-fish and Snails carry on development in other ways, the former in certain features in the head, the latter in the digestive and reproductive organs.

In the Acephala (the Shell fish) it is the breathing process which is emphasised, from which there is a constant secretion of carbonic acid. The mantle of the mussel is continually radiating carbonic acid, through combustion, at its meeting with the inner surface of the lime shell. The lime reacts with the carbonic acid.

Almost the only occupation of the mussel is breathing. Through this process the animal is continually forming itself, as it were. It constantly produces carbon-dioxide, but the exhaled breath always tends to coagulate and solidify. The mussel continuously casts out the hard substance into its near surroundings. Hence it deposits lime and thus the shell is formed. The mussel is really nothing else but the producer of Carbon-dioxide. The main constituents of the shell are carbon-dioxide and calcium. Thus the shell may be thought of as petrified exhalations of the mollusc.

Eventually the lime shells fall to the bottom of the sea, where immense masses of lime accumulate. These vast layers of lime are the result of nothing more than the remains of mollusc shells. After long periods of time, the lime crystallises and then it is very difficult to say how it was originally formed.

Only where the organic and the inorganic meet, and the protein substance touches the lime substance, and are in a state of balance does the precious-stone formation arise – mother-of-pearl.

Anyone, who has knowledge of pearl-fishery, knows that the most beautiful pearls are found in poor-looking shells. The pearl arises out of a kind of illness, or it would be better to say a kind of healing process in the mussel. We do not need to consider the illness, which is healed by producing the pearl. Healing takes

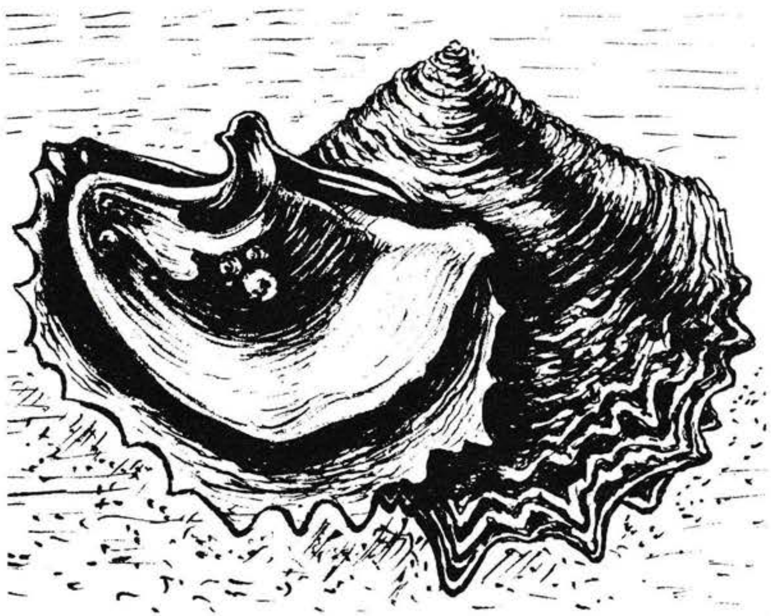

Fig.18 Pearl Mussel, and shell from inside.
half natural size.

place in the mussel when harmony is restored; the result is the pearl.

Some kinds of mussel have the tendency to have their harmony disturbed continuously, and these form pearl-substance particularly well.

The Cockle, or mussel of the pilgrims, does not produce much mother-of-pearl, it is more concerned with the **form** of the lime shell. Some other mussels concentrate on the forming of protein. Such are the oysters, much sought after by gastronomists. Here nothing much is done for the lime shell, only the protein is important. Oysters are cultivated artificially, but this is not easy. During cultivation they often die, as they are very delicate and sensitive, and have a tendency to a sort of skin gout, and they are always in a condition from which it is easy to pass into a state of putrefication. Here is the pure culture of the protein substance, whilst the lime substance is completely ignored.

With the Pearl Mussel, the protein and lime are in balance. In other mussels the lime is of the chief importance. In the oyster it is the protein which is the prime consideration.

Let us now turn to the third group of Molluscs. These are the snails. They are quite different from the Mussels, which develop their breathing; around their soft bodies they have a shell of lime.

The third group, the snails, are rightly named Gastropoda. They have a foot which is also a stomach, and they glide along on this foot.

The snail shells are not like those of the ammonites. They do not grow towards the back, but swing either to the right or left, usually to the right. Snails seem to have an asymmetrical form. They mostly live in water, but there are also species of land snails. These have lungs; water snails have gills.

The base of the snail is the foot, upon which it glides along on a slimy track, which is produced by itself. At the front there is a structure which is both a sight and a scent organ. The snail can push out or withdraw the two projections, somewhat like fingers of a glove.

Snails have very slow movements and are very phlegmatic. They are more 'down to earth' than the other molluscs. They have relatively large reproductive organs and digestive systems, both of which are at the base of the soft body. The mouth is on the foot, near the reproductive organs. The continuation of the digestive system, and all other essential organs, heart, lungs and liver, are above, within the shell. The stomach extends from left to right, and the well-developed liver is on the right.

Snail shells have great variety of form. Some are flat , others pointed, some are narrow, others broad. Within the shell is a spindle which looks like a spiral staircase. There are all sorts of whorls and coils. Some snail shells have interesting appendages, especially those of snails which live in the surf. These adapt themselves to the movements of the sea, and are often quite lively. Land snails are much more sluggish.

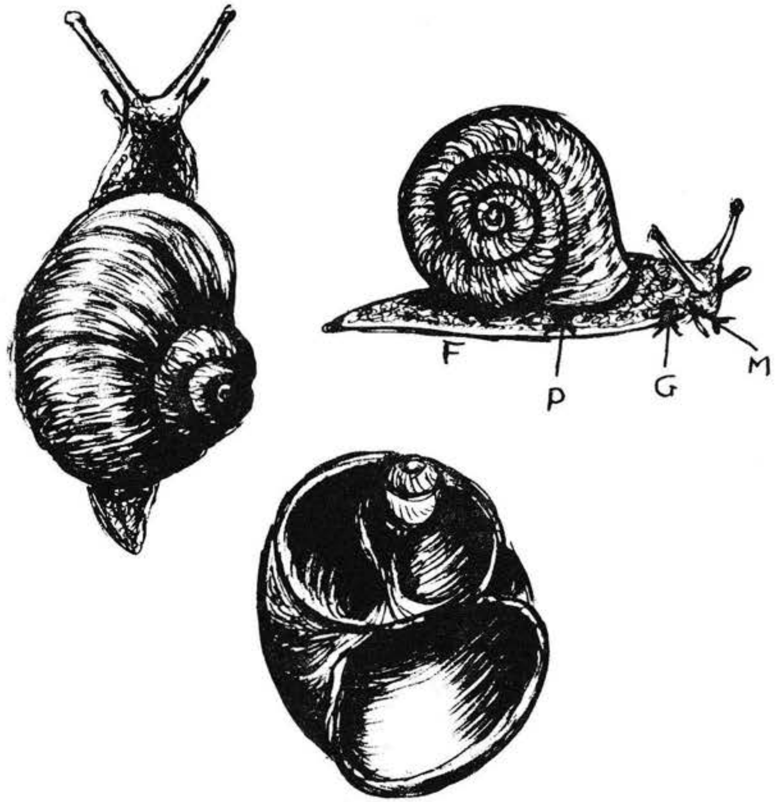

Fig.19 Land Snail
F – Foot P – Pneumostome G – Genital aperture M – Mouth.
Shell with part removed to show Columella.

Very interesting, too, is the so-called Storm-hood or operculum. Just as mussels can produce mother-of-pearl, so snails can produce something very similar to china or porcelain. Not only lime, but other substances are involved. It is interesting, too, that some snails can produce certain pigments, such as the Tyrian purple. Snails are very much affected by light and darkness. So, too, are they influenced by the different phases of the moon. They have strong links with the watery element.

Two different principles of form seem to be struggling with each other in the shells. One is the spiral and the other the

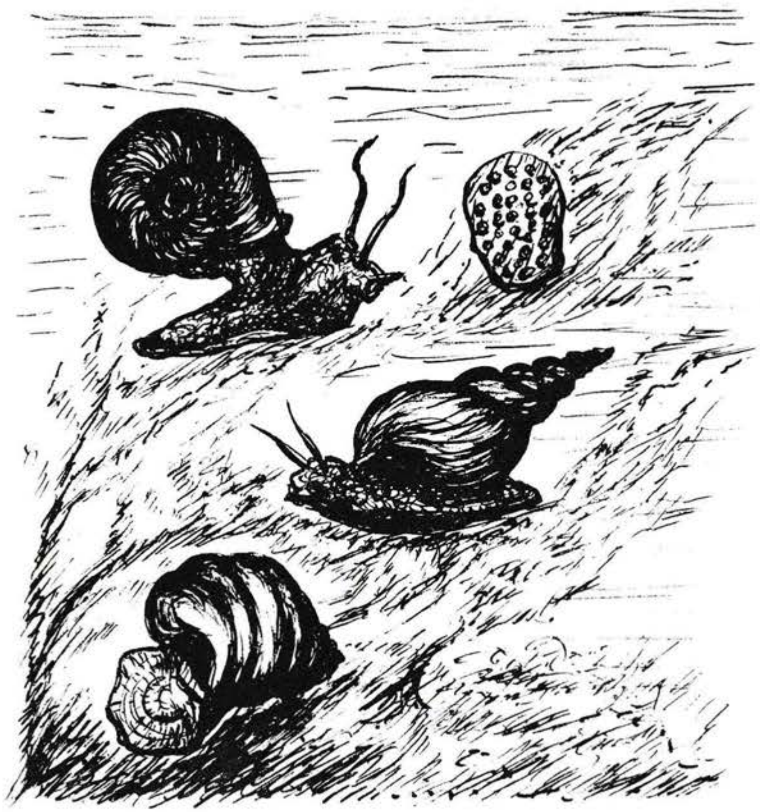

Fig.20 Fresh-water Gastropods (*natural size*)
1. Ramshorn Pond Snail and its eggs 2. Spiral-shelled Pond Snail
3. Fresh-water Winkle.

triangle. The result is sometimes almost a tetrahedron modified by the spiral curves. Another fact which is of interest is that the snail treats the shell as a home. The soft-bodied creature retreats into the shell. This may be compared with the relationship of the soul-life of Man to the physical body.

Shells have been used for many purposes. The Kauri-shells used to serve as coins. Then there is the interesting Triton's horn. Every Roman legion had a Triton's horn. This was a kind of conch-shell which was used as a musical instrument. A deep, powerful sound somewhat like that of a tuba could be produced with it. If such a shell is held to the ear, certain musical tones can be heard, for the shell is built 'musically'. So too are many other shells of the molluscs.

Part of the human inner ear is formed like a snail's shell. We could describe the Snail and its shell as an ear, living its life as a free-moving individual entity, with certain necessary appendages.

The Protozoa are closely linked with the Mollusca. Among the Protozoa there are many which resemble mollusc forms reduced to a microscopically small scale. One is like a tiny Nautilus; others resemble minute snail shells. Both Protozoa and Mollusca contribute much to the formation of the earth's substance; the former provide the chalk rock formations, the latter the limestone.

There are many indications that the Mollusca have a very long evolutionary history. The Cephalopods come from an ancient past like the Pachyderms (the mammoths and elephants). The ammonites are the remains of cuttlefish.

The Cuttlefish and the Snails are in contrast to each other, in several ways. The former are linked to the far past; the latter point to future evolution. While the one looks back to the Pachyderms, the other shows certain transitions towards the worms. The same forces, which produce shells in the molluscs, are set free in such an organism as the earthworm, and work in the surroundings of the animal.

The whole group of Mollusca is distinguished by the contrast between the formless protein of the soft body and the well-formed hard shells. These animals produce two kinds of secretions: the slimy protein and the hard lime. It is the connection between the half-fluid and the solid which is important in the formation of the shells.

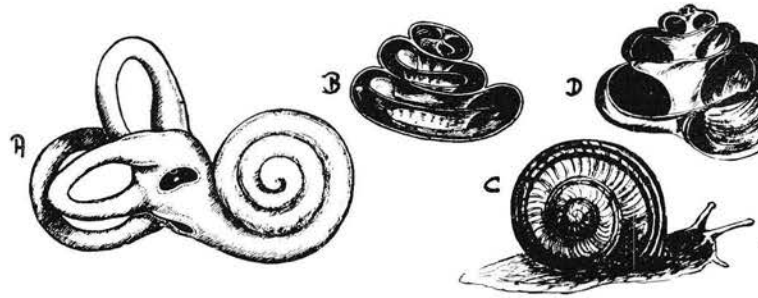

Fig.21 Human Ear and Snail Shell
A – Inner ear of man (*cochlea and semi-circular canals*)
B – Section through cochlea of man
C – Snail D – Section through snail shell.

Thus, in conclusion, there are three groups of Mollusca:

1. In the **Cephalopoda** the eyes and nervous system are highly developed.

2. In the **Acephala**, the shell fish, the respiratory system is most important, the wonderful breathing system produces the balance between soft body and hard shell.

3. In the **Gastropoda**, the digestive and reproductive systems are more accentuated in development.

The Mollusca show, in the three different types, that animals represent, in the form of their organisms, the same forces as those found in human organs, but developed in a one-sided way. What is balanced, and in harmony in the human being, appears in the animals in such a way that one organ overwhelms the others and gives the whole character to the being which it forms. An example, as already given, is that the organ of hearing is a mollusc.

Thus, the Mollusca form a very important transition in the animal kingdom. They are quite different from the Coelenterata and the Echinodermata. The plant-geometrical-blossom systems are no longer to be found in the animal kingdom. With the Mollusca we have come to a quite different sphere, which we shall understand more fully when we have studied the higher animal groups.

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EUGEN KOLISKO, one of Rudolf Steiner's most distinguished pupils, was educated at Vienna University as a doctor of medicine. He was also an authority on the Natural Sciences and History, and was a born teacher. As a lecturer in medicine, zoology, chemistry and history, he was much in demand, both in Europe and America. He died in London in 1939, at the age of 46.

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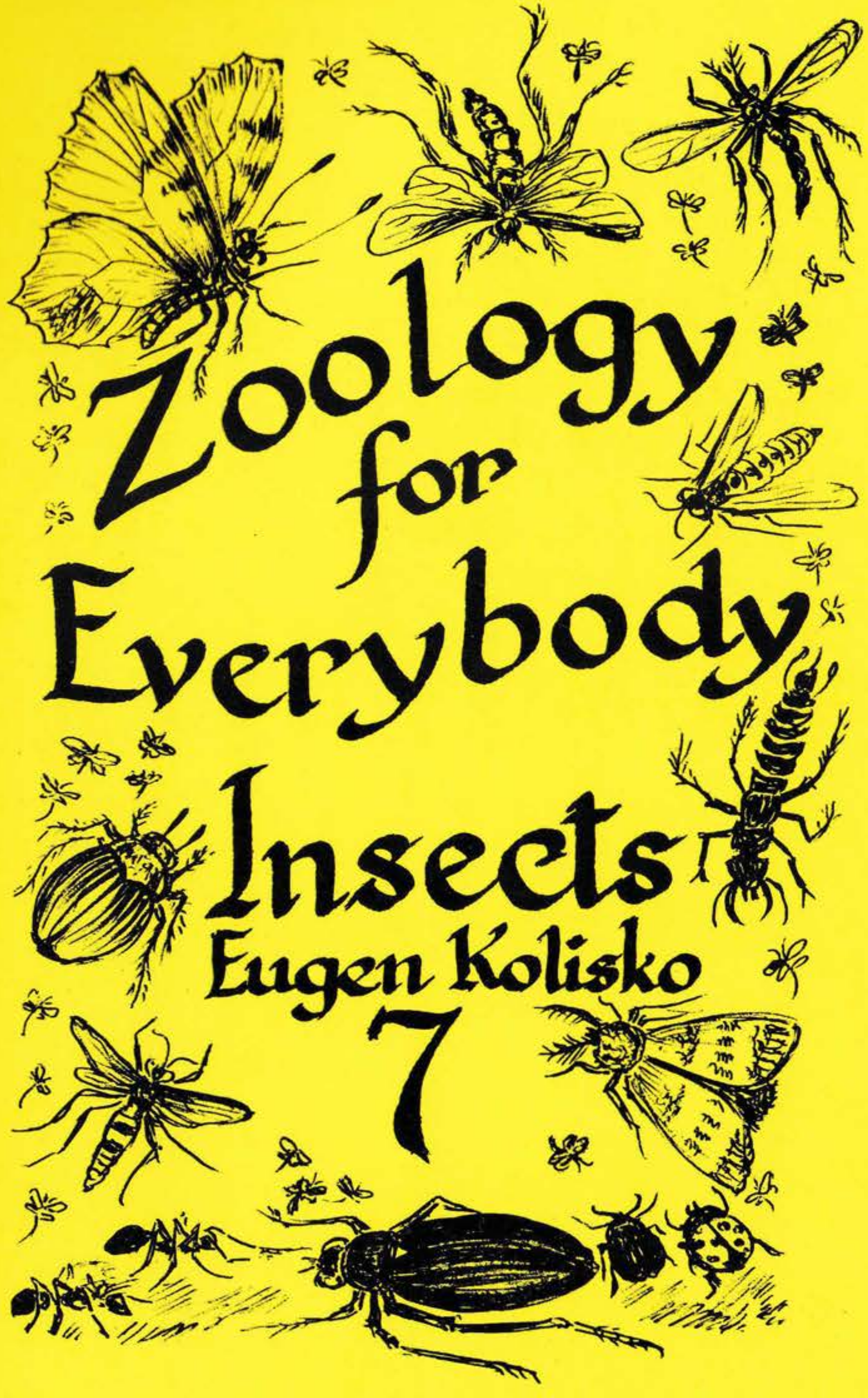

Zoology for Everybody

Insects

Eugen Kolisko

7

ZOOLOGY FOR EVERYBODY

A Series of Lectures

by
Eugen Kolisko
(M.D. Vienna)

11th. Lecture
Insects

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Introductory Note

Dr. Kolisko intended to write a book on Zoology incorporating the material contained in his series of lectures given in 1932. This was not accomplished in his brief life.

Soon after his death, Mrs Lilly Kolisko published the first two lectures. In 1944 she suggested sketches which might illustrate Lectures 3 and 4, on the Mammals, which we published in 1979.

In 1980, with the help of Gladys Knapp, we were able to publish a further volume on the Protozoa – Zoology No.4; in 1981 volumes five and six were published – Coelenterates and Echinoderms, Tunicates and Molluscs.

Now in 1986 we are publishing the final two lectures – this booklet on Insects and Zoology No.8 on Amphibians and Reptiles.

We are again greatly in Gladys Knapp's debt for her continued efforts in translating and sketching the material for this series.

A.Clunies-Ross. Bournemouth, July 1986

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ZOOLOGY FOR EVERYBODY
LECTURE 11

INSECTS

Today we will consider another group of animals: the ARTHROPODA (insects; centipedes; spiders; and creatures like the crab). These form an enormous group, which is widespread throughout the world.

The Insects are especially representative of Arthropods. They are most fully characteristic, and show all the distinguishing features of this group. Apart from the Insects, there are other creatures which combine the characteristics of the Arthropods with certain features of other animal types. Thus there is the central group of the Insects, and different, less characteristic kinds of Arthropods, which are nevertheless closely related to the Insects.

The Insects, (Class INSECTA, of the Phylum ARTHROPODA), are so called because their bodies are divided, very distinctly, into three main sections: the head, thorax and abdomen:

1. The **Head** consists of the mouth parts and sense organs.
2. The **Thorax** or middle part of the body has the organs of locomotion: Three pairs of legs and the wings.
3. The Insect's **Abdomen** contains the digestive, reproductive and excretory organs.

The Insects are quite different from the Worms, which also seem to have sections. Whereas in the Insects everything is divided into completely different sections, in the worms everything flows in waves, which are similar to each other.

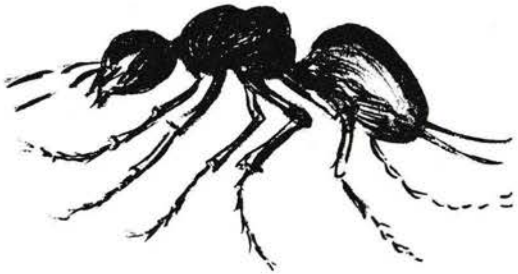

Fig.1 Wood Ant
(much enlarged)

The Ant shows the division into three sections especially clearly. The three parts: head, thorax and abdomen seem almost separate, so decisively are they divided. Here the differentiation has progressed to an advanced stage.

Today, we will devote our time to the insects, and will consider the other types in greater detail later on. The numbers of insects are so vast; these creatures show such an infinite variety, and they are found so extensively, that we will confine our studies to this group at present.

It is remarkable that the Insects, as a group, have a very strong connection, not only with the earth and with the watery element, but most of all with processes in the atmosphere. They are closely linked with changes of the seasons, with the course of the sun, and all that is influenced by the sun during the progress of the year. The insects are also very closely united with the plant kingdom. Insects and plants form a mighty unity. It is only in books that we usually find insects and plants separated! The truth is that insects and the plant kingdom are bound together by innumerable ties. In reality all cosmic influences are working in both of them. All the processes working in the atmosphere of the earth have a strong influence on the plant kingdom and also on the insects.

The Sea anemones and jellyfish and other soft – bodied creatures are connected especially with the **sea** The worms are linked with the **earth** and the soil. The Insects form a group which is related to a life in the **airy realm**. Not only to the solid earth, nor to the watery element, but to a far wider sphere are the insects connected. This sphere extends far out into the whole encircling atmosphere, and to the influences which work into the air from the sun and from the other planets. The light and the warmth within the atmosphere are also potent influences, coming to expression

within the insects as formative forces. Therefore we find great variety of form among the insects.The forces from the cosmos give the organisms of the insects an extraordinary refinement. This is especially apparent in the butterflies.

Here is a brief survey of the many types which belong to the Insecta. Besides the numerous Butterflies, there are the various kinds of Bees, Bumble – bees, Wasps and kindred insects. The Beetles are a large group consisting of innumerable species. These are three strikingly characteristic groups of the Insecta.

Then there are the Dragon – flies, the Locusts and Grasshoppers, and the night – flying Moths. Eventually the whole vast army of insects shows a downward trend in various species, a deterioration into a certain formlessness. Something happens to the insects which also takes place among the worms.

We find that, in Nature, some animals exist, adapted to earthly conditions, in a normal way. Others are adapted to a life in the airy realm. In both cases, there are numbers of creatures which are on the way to becoming parasites. Such are fleas, bugs, lice: insects which have deteriorated and become quite decadent. These are linked with all kinds of organisms, in which they develop and unfold their activity. There is a whole net of connections linking parasitic creatures and their hosts.

These decadent insects are diametrically opposite to the Butterflies. The Butterflies show an exceptional refinement of form and a spiritualisation of material substance This is a result of their life in the airy realm, and what works into it from the cosmic forces.

This wide range, from the Butterflies to the parasitic insects, comprises the insect class. All have something in common in their structure, although they are such a vast number and have such varied forms.

Phylum Arthropoda

Insecta:-
Insects, Butterflies,
Bees, Wasps, Moths.

Myriapoda:-
Centipedes,
Millipedes.

Arachnida:-
Spiders, Mites, Ticks,
Scorpions.

Crustaceae:-
Crabs, Lobsters,
Woodlice.

Fig.2

Some people enjoy systematic classifications; these can find full satisfaction for their interest in the study of Entomology, that is the study of insects. But many people are interested in insects without going into scientific details about them. There is scarcely anything so widely collected as insects, because of the great variety of kinds among them. There is incredible diversity in the widespread world of insects. When compared with other animal groups in Nature, the insects are remarkable for the amazing variety of form produced with such a small amount of substance. The Butterfly,the epitome of refinement and delicacy, consists of the least possible amount of matter. It eats scarcely anything, and its life – span is exceedingly brief. But how wonderful its perfection of form! The body of the Butterfly, separated from the wings, is wormlike. The fine powder on the wings is the most refined substance imaginable. What there is of material substance is exquisitely formed. Every colour possible gleams on the wings; the fine powder gleams and sparkles like tiny metallic scales. This dust on a Butterfly's wing is matter in its most subtle

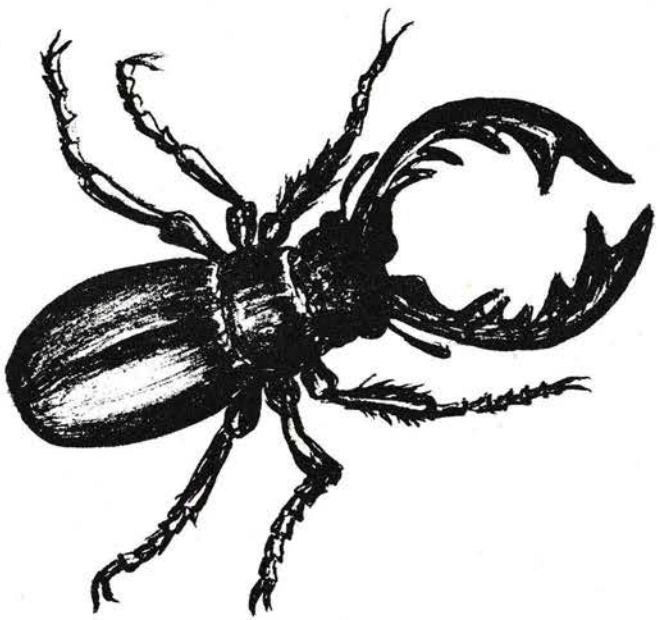

Fig.3 Stag Beetle
(natural size).

form. It is the most delicate substance which can be produced in an organic process, refined by what works in the light, warmth and cosmic influences of the surrounding atmosphere.

Without doubt, it is among the Insects that we find the greatest refinement in development of form in the Animal Kingdom.

Basically, the body of the Butterfly shows a series in its development. If we consider the separate parts, we find a worm – like section. Above are the wings.

An Insect consists of three different parts. Here is a specimen of a large insect: the Stag Beetle. We see the three separate parts: Head, Thorax and Abdomen. But we cannot take the Head, as such, quite seriously! Nor, indeed, can we speak seriously of "legs".

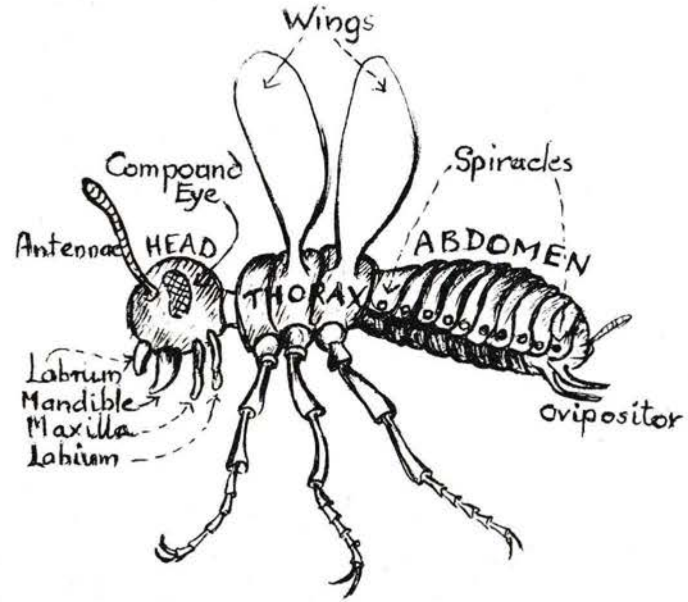

Fig.4 Diagram of Insect Structure
Head Antennae; Labrum and Labium; Mandibles; Maxillae.
Thorax – 3 segments: – 1 pair of legs; 2 legs and wings; 3 legs and wings.
Abdomen with Spiracles or breathing holes.

There are always three pairs of legs, and so Insects are sometimes called HEXAPODA (six legs or"six–footed"). This is a distinguishing characteristic of the Insects. The legs are attached to the middle part of the body, the Thorax. This is also a distinguishing feature of the insects. Any creature which has not six legs is **not** an insect. Thus the Spider, which has eight legs, is not an insect, although it is an Arthropod, a near relative.

The six legs, found in all true insects, are not a chance happening. The three pairs of legs, are on the middle part of the body, which is itself divided into three parts. On the thorax there are usually two pairs of wings, one pair hard and often horny in texture, and another of softer material.

The back part of the body, the abdomen, which contains organs of digestion and of propagation, never has legs, and it is separated from the rest of the organism.

The front part of the body, the head, also consists of three parts. There are the organs for eating: the upper jaw, lower jaw, and lower lip. There is also a pair of antennae on the head, which look like limbs, but they are transformed into sense organs. It is difficult to say exactly what the antennae or feelers are. At the base they are limb–like; then they become chewing instruments and then sense organs.

Thus we find seven pairs of limb–like structures:

One pair of Antennae on the head.

Three pairs of chewing organs on the head.

Three pairs of legs on the thorax.

This is the characteristic structure which we find again and again in the insects.

Fig.5 Earth Worm

Here, if anywhere, is evidence of what is called in Anthroposophy, "the etheric body". The etheric always repeats the same form, wave after wave, as in the body of a worm. This is connected with the **fluid** element.

This is not the case with the worms, where this differentiation into parts is concealed by the middle portion of the worm. The head and the tail of the worm are made similarly to the middle part of the worm, which seems to extend over the whole creature. In Zoology, many are the discussions about whether it is justifiable to separate the worms as a Class from the insects.

Many consider that anatomically no essential difference can really be found between the two classes. In the worms, the structure of the middle part of the body overwhelms the other two parts. In the insects the opposite happens: the structure of the body is separated very decidedly into three parts; only the back third, the abdomen, retains the rings. The Centipede and Millipede form a transition between Worms and Insects; they look like worms but have legs.

Fig.6 Millipede
(natural size).

Why do Zoologists find that the structures of Worms and Insects are similar anatomically, and yet, to the casual observer worms and insects look so different?

Anatomically, the structure of insects is not very different from that of worms. It is similar, except for the position of the circulatory system, and that of the ventral organs, which are at the back of the body in the insects. The nervous system is a long double nerve–cord on the underside of the insect, along the whole length of the body, reaching into an undifferentiated space of fluid at the back. It was only in the nineteenth century that Carus discovered that insects had a circulatory system. The"blood"is usually yellowish in colour.

Now we may ask:"What is it that displaces the circulatory system of the insects, that overpowers it, thrusts it aside?"It is the breathing system which is peculiar to the insects. They have holes,"spiracules", in the abdomen, through which air streams into their bodies. From the spiracules, delicate tubes branch off and spread right through the body,

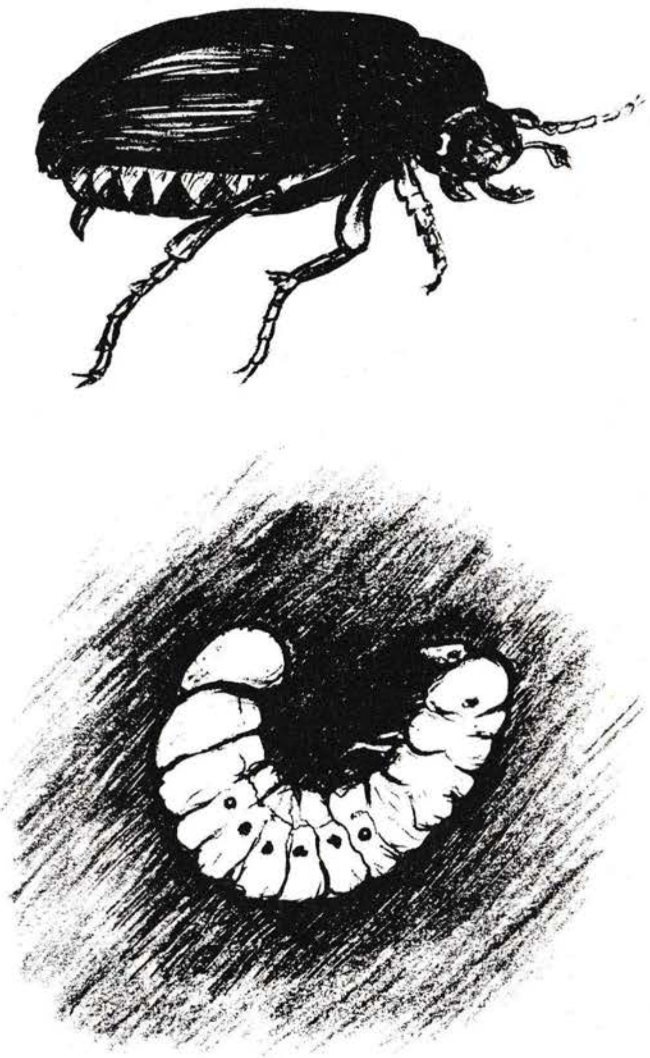

Fig.7 Cockchafer or May Bug – Insect and Larva
Larva lives up to 3 years in soil and may cause much damage to crops.
(Twice natural size).

even into the wings. If we imagine this network of infinitely fine tubes separated out from the body, we have a real "image" of the insect's form. Just as the skeleton reveals the form of an animal, so the tracheae – system gives a picture of the insect form.

We should think of a butterfly, a bee, and other insects as consisting much more of air than of solid substance. Just as a bubble is completely penetrated by light and air, so is the insect's body. The delicacy of this "air – body" is connected with the capacity for flying possessed by insects.

The Cockchafer (or May Bug) has a heavy body, and must first of all "hum itself up" before it starts to fly, but most insects find this unnecessary: the tendency to fly is built into their organisms. Thus insects have quite a different anatomy from most animals. Though insects really have the body of a worm; they have developed fine air – filled bodies, light as floating bubbles. The fluid element has been over – powered, thrust away.

It is interesting to watch a butterfly emerging from its chrysalis, unfolding its wings and drying them out. Such a process is soon completed, for a developed insect does not contain much fluid.

Imagine the circulatory – system of an insect increasing, while all that is connected with wings and limbs decreases, and shrinks. The result is the form of a worm!

Here, if anywhere, is evidence of what is called in Anthroposophy "the etheric – body". The etheric always repeats the same form, wave after wave, as in the body of a worm. This is connected with the **fluid** element.

Butterflies are fantastic, improbable appearances in the Animal Kingdom! It is only because we are accustomed to seeing them, that we accept their unusual form, and take them for granted. We cannot explain why they are so delicately made and why they flit about. The cause of their exquisite refinement of form, and their ability to fly is only explained by influences coming from outside, from the light and from the air. Something similar happens in the case of Birds*, about which I have spoken in earlier lectures. The bird's body shrinks and becomes hardened, but its beautiful covering of feathers develops. The colourings and the forms of the plumage show that they have been drawn out of the organism by outside influences. The real being of the bird is not within its body, but outside and around it. In the insect something similar happens,

*Birds by E. Kolsiko

but to a more advanced degree. The insect is more spread out in the cosmos and it is less individualised than the bird.

We can observe this at dawn. As the sun rises, the insects begin to be active; at sunset they withdraw. Plants, too, behave as the insects do, and respond to the sun's rising and setting.

The insects are completely connected with the airy realm. It is their breathing system, the tracheae, which links them so strongly to the air. Here we see the difference between an ether-body, which always repeats the same form rhythmically, and the effect of cosmic influences which comes from the stars. The insect lives in the airy element, and the air moves into it through the spiracules; through the tracheae – system it is permeated completely with air. The air has a stimulating effect and makes everything mobile, and this results in variety of form. The insect really produces a picture, an image, of what the air does to it. Because air enters through the tiny spiracules, and passes through the fine tracheae tubes, the insects develop thin, spider-like legs. These cannot be considered as legs of flesh and blood! They are only the result of the insect's breathing system. An animal, such as the frog, which has a lung, has much more massive legs. The tracheae system of the insects is the cause of the fine, spider-like legs.

Thus, although the insect is basically worm-like in its structure, yet it is differentiated through its life in the air. So far, whenever I have spoken about the insect, I have always meant the perfectly developed insect: the IMAGO. The finished insect is really an "image", a picture of what the air has made of it, so the word "imago" is really a good expression. Insects are hovering images, formed from the smallest amount of material substance. We are amazed at the variety, achieved with so little. If we compare insects with other, more bulky animals, such as the snail or cuttlefish, we wonder that the smaller insects show so much more variety of form: so much has been achieved with such a tiny amount of material.

We have already mentioned that insects are much less individualised than most animals. Many live a collective life, in an organised community. This is a characteristic of the insects, with which we will deal later.

We have described how the structure of the insect organism is divided up **spatially;** the different parts are arranged in a series: head, thorax, abdomen. The insects also go through a series of developments in **time.** This is most interesting. Insects pass through a series of metamorphoses, which proceed according to certain laws. First there is the egg; then the

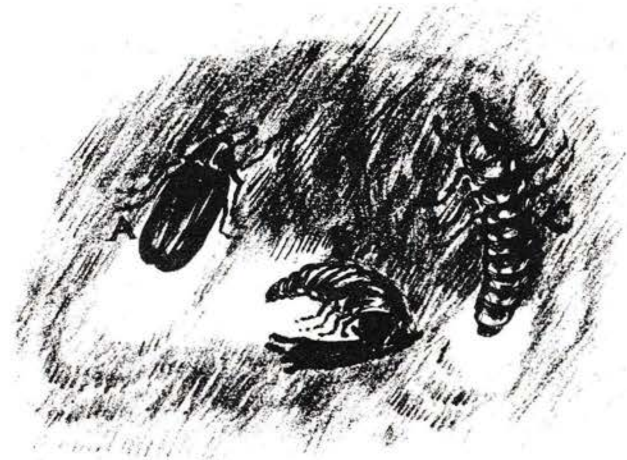

Fig. 8 Glow Worm
A) Male; B)Female with snail; the female is little different from the Larva C), except in size.
Lives on grassy banks; feeds on snails; male flies at night.

larva or caterpillar; then the pupa or chrysalis. The final stage is the perfect insect, the Imago. There is nothing like this in any other part of the Animal Kingdom: this organised series of metamorphoses. Just as the insect is divided into sections in **space,** so it always passes through a series of quite different forms in **time** before it is fully developed. The more perfect the transformations in the different stages, the more perfect is the insect which appears at the end.

The change of form in the insects may be compared with the metamorphosis of plants. The plant grows from a seed. Then there is expansion as the stem and leaves develop; this is followed by contraction of the leaves into the calyx of the bud, followed by expansion as the flower opens its petals.

The eggs of insects are usually laid in the earth, or so that they have a connection with the earth. In the case of parasitic insects, the eggs may be laid within an animal. At this stage the egg falls away from the airy realm, with which most insects have such strong connections. The eggs must pass through a period of darkness, just as darkness is necessary during the germination of a plant seed. If the eggs of the insect are not laid directly in the earth, then they need something which has grown out of the earth, such as some plant formation.

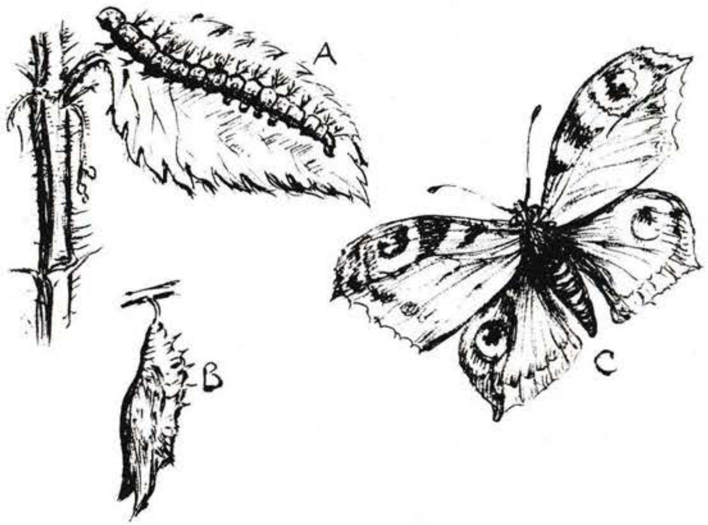

Fig.9 Peacock Butterfly
A) Larva – a green, hairy caterpillar; seen here on a Stinging Nettle Leaf.
B) Pupa – this looks as though it is made of metallic gold.
C) The Imago – perfect insect.

The egg becomes a larva or caterpillar. This stage obviously is a repetition of the worm-like stage of development. The creature is a worm, with legs, though the legs are not well developed. Sometimes a caterpillar may be brightly coloured; some have striking patterns, others are hairy. But the true nature of the caterpillar is revealed if it is dissected. Then we see that it consists of a skin, completely filled with leaves, crumpled together and broken into pieces. Caterpillars have an enormous capacity for eating, most voracious appetites. They eat immense quantities of leaves.

The earth-worm, too, has an enormous appetite. It eats its way through the soil. It is as though two streams approach each other. Does the worm eat the soil, or does the soil flow through the worm? The earthworm is a benefactor to the earth; it transforms the soil and gives it vitality. It lives in the soil, and what has passed through the earthworm gives life to the soil.

Not so the caterpillar! The caterpillar appears greedy. The leaf substance is drawn into the creature, and then undergoes transformation. The result is that the caterpillar becomes a pupa, a chrysalis. What happens next can be seen most beautifully in the Silk Worm.

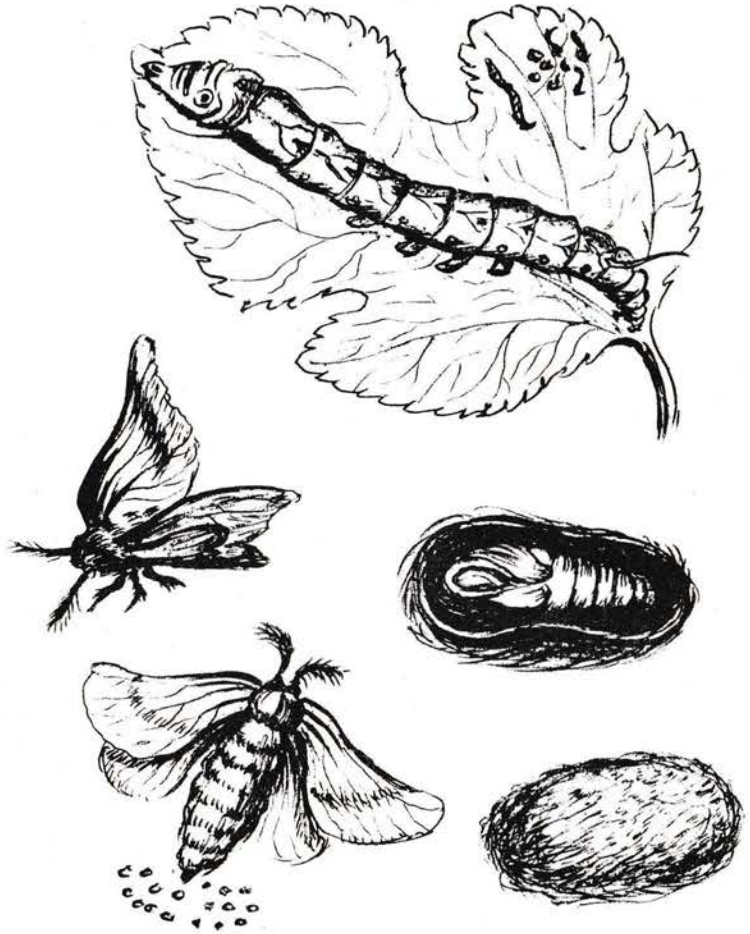

Fig.10 Silk Worm
(from egg – larva – pupa – to imago)

The Silk Worm caterpillar eats the leaves of the Mulberry Tree. In doing so, it bundles the leaves together, and this is what forms the caterpillar itself. The Silk worm larva or caterpillar eats through the world of the Mulberry Trees, until it begins to develop something new: a cocoon. The caterpillar acquires a strange capacity: it spins a thread of fine silk, which it weaves into a cocoon. Within the cocoon the larva becomes a chrysalis and enters into a period of rest. That which is inside the chrysalis is chaos, a half-decayed substance without structure, which, strangely enough, does not die. Most remarkable is the complete transformation which takes place within the chrysalis during its resting stage. The chaos within the caterpillar, the substance without structure, is transformed; it might be compared with what is called"chyle". The more radical the destruction and transformation, the more beautiful is the Imago, the insect which emerges, especially in the case of the butterflies. The caterpillar has eaten voraciously, shedding its skin again and again as it grows larger and larger. When it has acquired a certain size it stops eating; it contracts. It consists of substance in a chaotic form, with no structure. It is in a state of ruin. The chrysalis or pupa remains in a state of rest. Then comes a resurrection. This has always been regarded as a happening which takes place only in soul life. The transformation from pupa to Imago in the insect has always been thought of as a symbol of resurrection. Matter has been led into a state of nothingness. Then something arises which we cannot understand according to the laws of chemistry. Remarkable chemical combinations point strongly to a connection with the effects of light. Light has streamed in from the cosmos and has become transformed. Very little of the terrestrial element is there.

The Beetles and the Dragonflies also show this tendancy for a complete transformation. The Grasshoppers avoid the chrysalis stage in their development. The more deeply we descend into the world of the parasitic insects, the more is the pupa or chrysalis stage omitted. the larva which comes from the insect is so like the finished insect, that it can scarcely be distinguished from it. The larva does not transform into a creature of higher grade; it remains stationary.

There are three very different groups among the insects:

Butterflies
The highly developed types like the Bee
Beetles

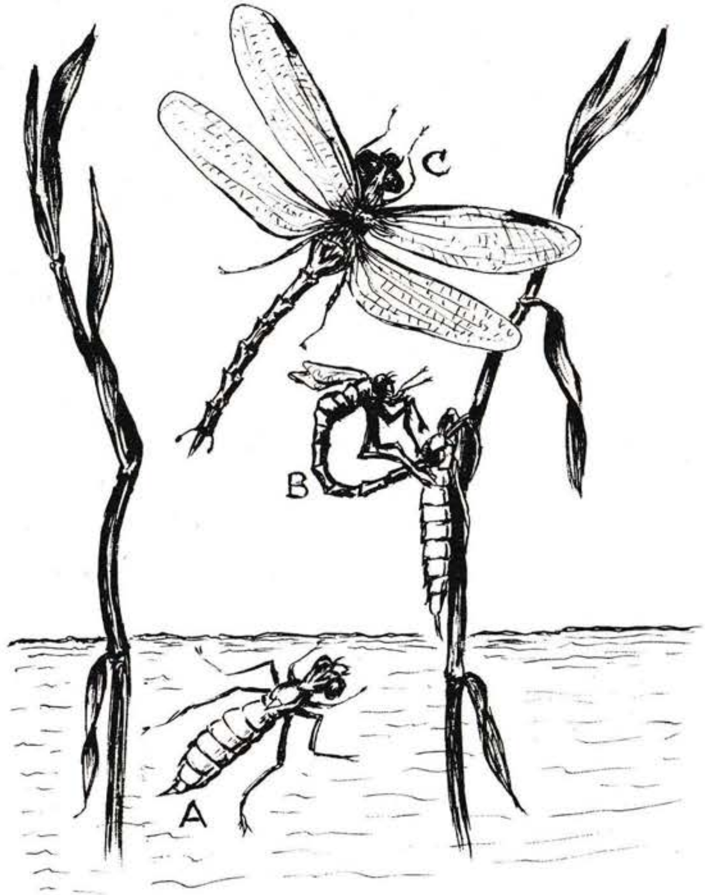

Fig.11 Development of Dragon Fly
A) Nymph; B) Dragon Fly emerging from Nymph Case; C) Fully Developed Insect.
Eggs are laid in water or mud. The young dragon fly is aquatic, living in freshwater.
At this stage it is called a NYMPH. The young nymph later climbs a water weed and comes into the air.

The Butterfly passes through pronounced stages of metamorphosis. It has a fine organism, the"light"body of delicate colours. Either this is produced, or the creature develops the capacity for spinning. These insects are completely different from the Beetles. Among the Insects there are coarser forms than the Butterflies, such as the night–flying Moths. Also we find insects which come near to the world of the Birds, others which resemble animal types, such as the Stag Beetle. These are strange looking creatures. The Beetles have hardened bodies, which are much heavier and coarser in structure than the Butterflies, and they live on the earth or in the bark of trees. There are the Dung Beetles which bury the corpses of small animals, and then lay their eggs in the carrion. Some beetles have strange forms, such as the Rhinoceros Beetle which has a horn on its"nose". Some insects emulate Humming Birds, as they suck

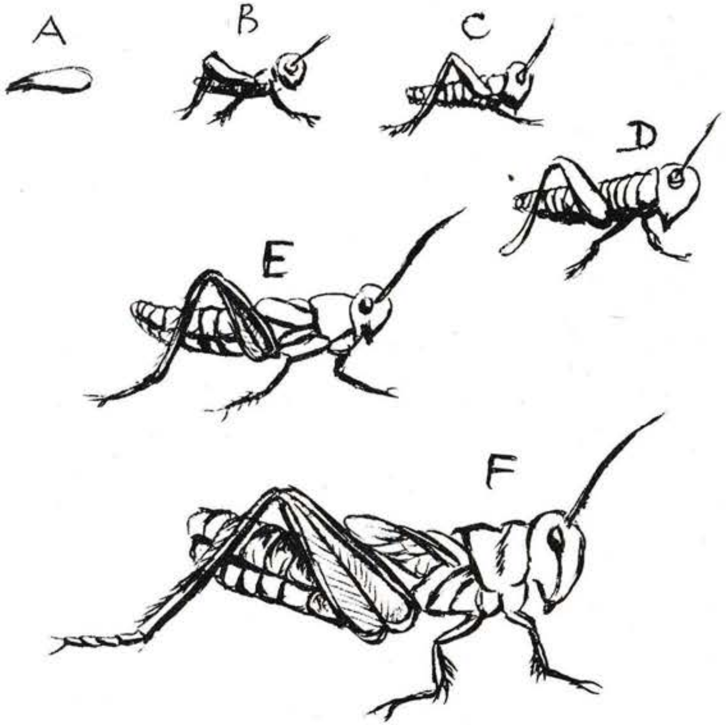

Fig.12 Development of Grasshopper
It does not develop through egg, larva, pupa to imago as the Butterfly does. It merely increases in size.

nectar from flowers with their long proboscis. All these are imitations in some way of other higher animals. They have a way of life which is more adapted to the material world. The larva of the May Bug or Cockchafer is a kind of counter – picture of the earthworm. the May Bug larva destroys all that the earthworm makes good. Although the good – natured May Bugs emerge from the larvae, yet there is, nevertheless, a destructive force inherent in them, which is opposed to the beneficial forces within the earthworm. the May Bugs increase in definite rhythms and have a detrimental effect on agricultural work. The world of the Beetle is opposed to the world of the Butterfly. One is more connected with the earth; the other with the airy realm and light above the earth.

Bees, and Bumble–bees have something which has always been compared with the Bear. Wasps are tiger–like; they have legs like the Butterflies, but their wings are much smaller and of a skin–like texture. Wasps live in communities.

Some insects remind us of the higher animals. Others are bird–like. Among the beetles is the Rhinoceros Beetle, which has a snout on its head. There is the Stag Beetle, with antler–like mandibles. This phenomenon of"mimicry"of the higher animals, is frequently found among the insects. Bees and Bumble Bees resemble furry Bears; Wasps are more like beasts of prey, and remind us of Tigers.

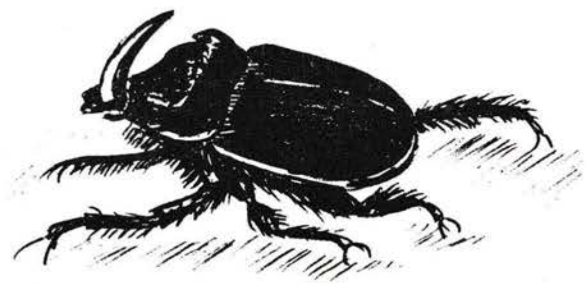

Fig.13 Rhinoceros Beetle – Oryctes nasicornis
(natural size).

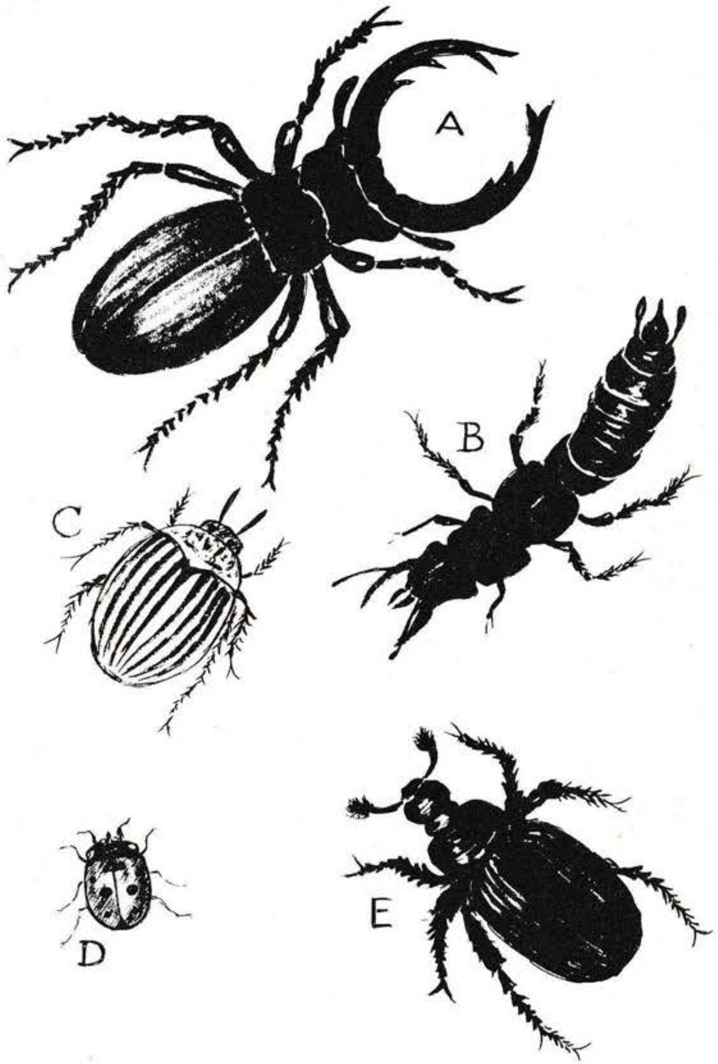

Fig.14 Beetles
A) Stag Beetle; B) Devil's Coach Horse; C) Colorado Beetle (Potato Pest); D) Seven Spot Lady Bird; E) Dor Beetle (Dung Beetle).
(one and a half times natural size).

In the tropics Bird and Insect forms begin to overlap each other. The Humming Bird's beak is transformed into a delicate trunk, with which it sips nectar from flowers. Among the insects there is the Humming Bird Hawk Moth, which hovers in the twilight. It visits blossoms, such as the Honeysuckle or the Tobacco flower, in which the corolla is in the shape of a long tube. It unrolls its long tongue (proboscis) to suck up the nectar.

The various form–producing forces are always in existence in the cosmos. Sometimes they work into insects, sometimes into other animal forms.

This brings us to another idea. Immense light can be shed on the development of the insect world by a suggestion of Rudolf Steiner's. He said that there is an **inner connection** between plants and insects. These two groups should be considered as a unity.

The Stinging Nettle provides nourishment for the Peacock Butterfly. The larva or caterpillar of this butterfly is difficult to distinguish from nettle leaves. The greenish caterpillars look like rolled up or twisted Stinging–nettles leaves, which, however, are mobile! It is interesting to compare the eggs of butterflies with the seeds of the plants on which the larvae feed. The egg of the Peacock Butterfly resembles the seed of the Stinging Nettle.

The larva or caterpillar contracts into a pupa or chrysalis. A plant also contracts before it forms a blossom. It forms a bud, within which are the petals, surrounded by a green cup–like calyx. Goethe founded his"Metamorphosis of Plants"on the alternating expansion and contraction process in plants. A similar alternation takes place in the insect world: egg expands to larva; larva contracts to pupa; pupa expands to imago.

Rudolf Steiner expressed the comparison between plants and insects by saying that a flower is a"Butterfly attached to the earth", whilst a Butterfly is"a blossom which is mobile and can fly away".

This comparison and metamorphosis should not be accepted superficially, but should be thought through in detail.
Some things about insects cannot be understood unless we start from the basis of an inner connection between plant and insect.

Both plant and insect are intimately connected with the cosmos. Light works upon both plant and insect, but with different effects. Nevertheless plant and insect live in intimate connection with one another. We must understand this,"Mimicry", imitation, is common among the insects. There are insects which look like wandering leaves. According to the views expressed today, grasshoppers and locusts resemble their surroundings for protective reasons. They resemble leaves so that their enemies cannot distinguish them from plant foliage!

But we can look on this from another point of view! We can consider that the locust or the grasshopper is only a mobile leaf. This is true when a swarm of locusts descends upon some crop, and speedily incorporates the leaves, so that the foliage becomes a part of their bodies! Grasshoppers and locusts are really differentiated leaves, only leaves which are mobile

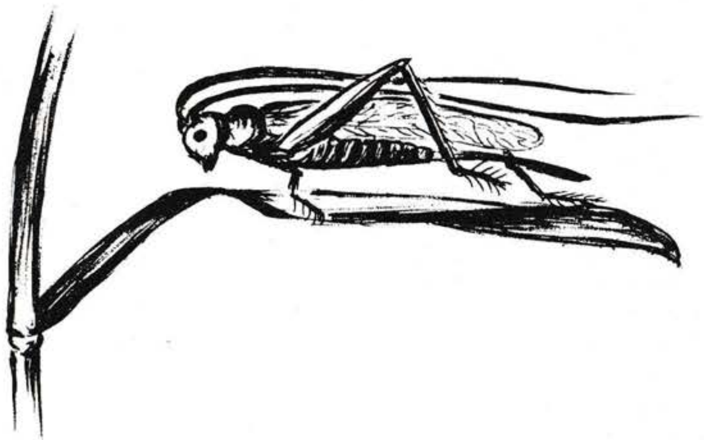

Fig.15 Common Green Grasshopper

and free from attachment to the earth. They have an enormous capacity for increasing their kind very rapidly. Vernanski, a research chemist, has written a very interesting book. He has tried to calculate how earth substance is built up from the remains of living creatures. We have spoken about how skeletons of animals have produced chalk and limestone rocks. Vernanski develops this thought. He considers the effects of vast swarms of locusts. He considers that the amount of lead and tin produced on earth over a period of ten years, may be accounted for as the result of what happens from the remains of a few swarms of locusts. Swarms of locusts may be considered as"wandering rocks". If the enormous numbers of insects are deposited on the earth, they provide a huge mass of decaying organic substance, which eventually forms a part of the earth mass. Vernanski calls this process"floods of life". He says such happenings are frequent.

We can see that locusts and grasshoppers are connected with leafy vegetation. We should not be surprised that these creatures resemble foliage in their outward appearance. the material substance is worked upon by formative forces, and an animal organisation appears, which is leaf-like.

There are Caddis Fly Larvae, which run about with pieces of leaf on their backs. If you imagine this process continuing into the organic realm, you come to animal"Mimicry"produced from within.

Other animal forms which resemble plants are the Stick Insect, and the Praying Mantis, both of which are stem-like in form.

Fig.16 Praying Mantis – in a characteristic pose
(Twice natural size).

There are many such forms of Mimicry, for which various explanations have been given, such as:"God arranges everything in a wonderfully harmonious way, and the Butterfly is protected from its enemies". In the eighteenth century, the English called this"Natural Theology", where Nature can be shown to be arranged"ad majorem Dei gloriam". This point of view became exaggerated, and caused irritation to people. We can experience this in Darwin. He studied these suggestions of "Natural Theology" and then arrived at his theory "Natural Necessity" and

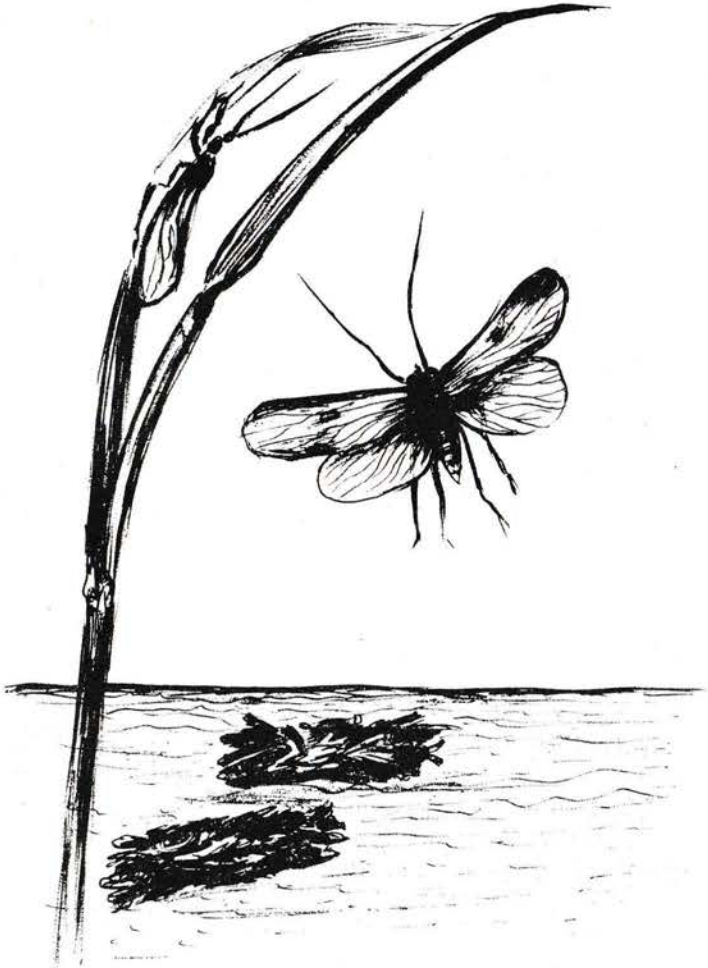

Fig. 17 Caddis Flies and Larvae
(larvae covered with pieces of plant, leaves and stems).

"Natural Selection". Instead of considering that Providence had arranged that an insect was in accord with its surroundings, Darwin suggested "Natural Selection" through breeding.

Darwin had a genius for observation. He progressed in thinking, in small steps, as he studied the earthworm. The Breeder marks these small steps; he cultivates slowness, and identifies himself with Nature. Darwin has confidence in Nature, and considers her capable of everything. Just as in Natural Theology, God was capable of everything, so Darwin considered Nature capable of everything. Thus Darwin produced his theories of"Natural Necessity"and"Survival of the Fittest". He explained Mimicry in insects by suggesting that the grasshopper most like its surroundings is the one most likely to survive attacks from its enemies, and therefore the one most likely to reproduce its kind.

This is just opposite to the point of view that there is an inner relationship between plant and insect. The formative forces work differently in the plant and insect, but the two are related and form a unity.

The Bumble Bee and the Foxglove flower seem to be made for each other; they fit together perfectly. If the Bumble Bee became extinct, so, too, would the foxglove plant disappear. The two rely on each other. The Foxglove could not produce seeds without the visits of the Bumble Bee. The two should be treated together, not separately.

Formative forces work differently in plant and animal substance. Plants absorb Carbon-dioxide, and, through formative forces working in the light, can build up their bodily structure from the Carbon. The Carbon is used in this way; the oxygen is given out. The plant produces leaf after leaf, as the plant utilises the carbon as food, through the working of cosmic formative forces carried by the light; the sunlight. The plant builds its body from the Carbon and grows up and up. Various Carbohydrates, the so-called"Carbonic-acid-Chains", various chemical combinations, are formed during the process. We might say that Chemistry, as well as the plant itself, grows during the process.

The animal cannot make its own food from Carbon-dioxide, nor can it grow up into the infinite, as the plant does. The formative forces work differently in the animal. The animal breathes in Oxygen, and, as a result, the whole metabolism of the creature is different from that of the plant. As the animal breathes in oxygen, it divides into many parts, into different organs and into limbs, whilst the plant goes on growing on and on, repeating leaf after leaf. The animal cannot make its own food, but something within it becomes free; it becomes mobile.

Fig.18 Bumble Bee and Foxglove

The plant remains static. The metamorphosis is an ascending process in the plant, an upward evolution. The animal, by contrast, follows a descending, a process of involution.

It could be shown that chemistry within plants and insects is linked with the metamorphosis in form. Inner material changes correspond to what has become a form.

It is interesting to observe the Silk Worm. The Silk Worm eats the mulberry leaves and takes in the formative forces within them as food for itself in the larva stage. Then it spins its cocoon, and the modified sunlight is spun out again as silk. But what happens to the Silk Worm, after it has produced its marvellous cocoon? It is exhausted. It can scarcely eat or fly, and it dies almost as soon as it has finished spinning the silk cocoon.

The flower, unlike the leaf, is not green and cannot absorb Carbon – dioxide and produce food. What happens? It withers and dies. If this were not so; if the blossom had wings and could fly away, there would be no metamorphosis within the plant.

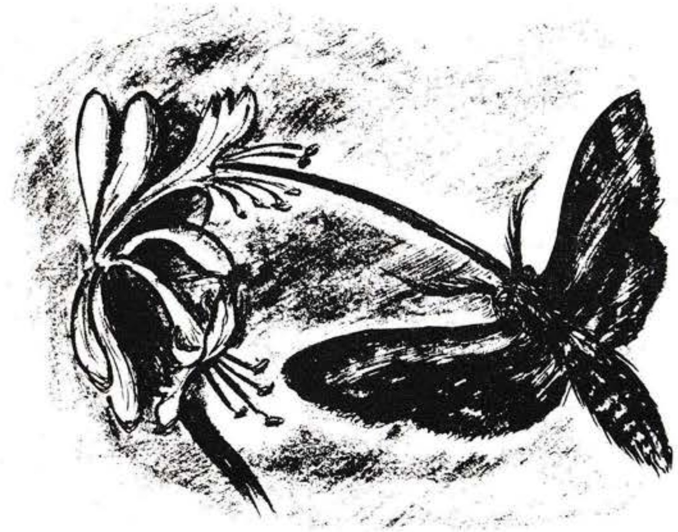

Fig.19 Humming Bird Hawk Moth
Sipping nectar in the twilight with its long tongue (proboscis).

Goethe could not think through the enormous realm of adaptation of insect to the plant world. He could not establish the full relationship between seed, leaf, bud and blossom to egg, larva, pupa and butterfly. He could not understand completely how the insects and the plant world are inextricably involved with each other. Each plant has a special individual quality. The forces which are hidden in particular plants, which have no blossom, are revealed in the animals which use the plants as food. The Nettle has no conspicuous flowers, but the beautiful Peacock Butterfly uses the Stinging Nettle as food, and reveals its formative forces in the glowing colours of its wings.

Both the old materialistic theories and Darwin's Natural Selection and Survival of the Fittest theories deal with the connections of plant and insect externally. Neither deals with the true inner links between plant and insect.

The Cosmos works in both in an intimate, inner way, and binds plant and insect together. Pollen dust is scattered on the wings of the Butterfly; in the plants it is in an inner form structure.

We must think through the inner connections between insect and plant. Here indeed we can observe"the deeds of light".

Another theme we must mention is the interesting way in which some insects live in communities. The insect world extends over a vast realm. The Bees form and live in Bee"states"or organised communities. So do the Ants and the Wasps. We cannot look upon single Bees as individuals. It is an illusion to think of Bees as separate in space. Why do the insects build communities such as the bee hive, the ant heap, the wasp nest? Because it is a characteristic of the insects to be divided into different sections. The Bee Hive is a complete unity. The bees may not be considered individuals because they are separated in space. An atomistic perception can never understand why there is a social life even in this primitive form. The Bee state is a unity, an organism in which the single insects move freely. Just as blood corpuscles move about freely in our blood, so do the bees in the hive. The temperature of the bee hive is 37 degrees centigrade, which corresponds exactly to the temperature of the human being. The single bees have no comparable temperature. The whole hive is an organism. The way in which the bee hive is usually described is not accurate; it is not sound. This is the remarkable truth. In the bee hive, the ability to propagate rests solely with the Queen Bee. It is strange how this comes about. The queen flies out. It is only on this nuptial flight that fructification takes place, and this happens only once.

The ability, to propagate has been taken into the queen's organism. She has time to lay infinitely many eggs every day. The real fructification takes place as the eggs are laid. The female organism, the queen, has the ability to lay eggs. there is a breeding sac in which the sperm is kept and this can go on living. It is the queen insect which can decide whether to combine egg and sperm or not. The queen can produce fertilised or unfertilised eggs. The unfertilised eggs become drone bees; the fertilised eggs become worker bees. This reproductive process is called Parthenogenesis (reproduction without the union of sexual elements). The Drones come into being from the unfertilised eggs; these are the males. The worker bees come into being from the fertilised eggs, but within the worker bees the female organism is stunted; the worker bees

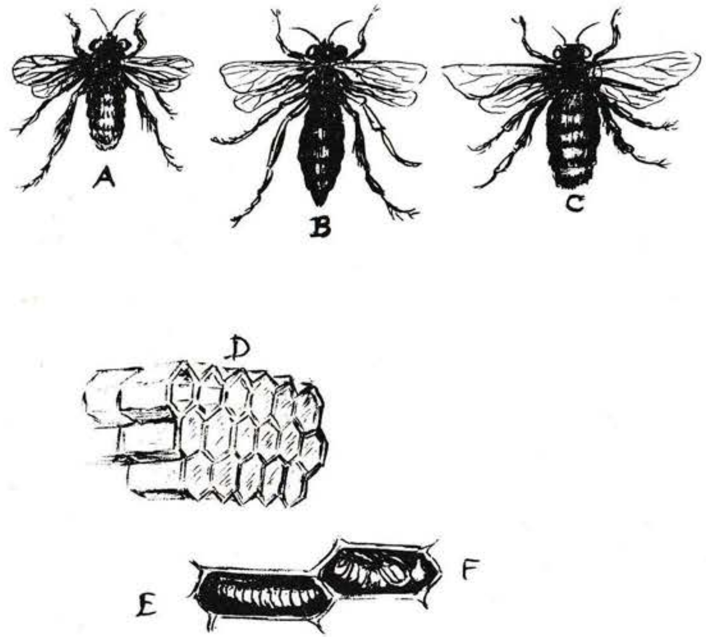

Fig.20 Honey Bee

A) Worker; B)Queen; C) Drone; D) Wax cells built by bees – back to back Larva in wax cell; F) Pupa in wax cell.

have female organisms but cannot reproduce. In a remarkable way the sexuality is so organised that it is removed from the separate insect and put into the whole. Therefore it is not surprising that the drones disappear; it is said that they are extinguished by the workers. Something from the drones is in the laying stream within the queen's organism, through which the workers come into being. This strange process in the bees follows a law which otherwise only takes place in an organism in which different glands separate off. In the Bee hive the whole hive is affected by the arrangement. Forces are working which do not come from the earth, but from the cosmos.

It is not difficult to recognise that a community of ants form a Mars state. The French research worker Fontenelle has written a book,"Le pluralité des mondes". But why should we travel to the planet Mars to see whether it is inhabited? On Earth there are Mars States and Venus States. The insects are not limited by earthly laws, but respond to those of the surrounding cosmos. The ants are a war-like community. They have a special relationship to the metal Iron. They behave like robbers and have warlike escapades. They capture prisoners, and carry them off as slaves. These captives are usually tiny insects of the aphis type which live on plants. The ants carry these little creatures to their ant heaps, and make use of them by feeding on their glandular juices. So the habits of the ants resemble those of marauding warriors. But everything within their communities is organised into the organisms of the insects. Cosmic effects work into the creatures.

Rudolf Steiner describes the bee community as unique in its perfection. He says that this is because sexual forces are transformed completely.

Now I would like to suggest some conceptions that we should have in order to develop some understanding of the insect world. We must follow the metamorphoses in the series of changes which happen in time and in the organic changes of the insect's structure. We must consider the effects of the light, air and warmth on the insect. These effects lead us to study the inner relationships between the insect and plant worlds. We only learn to understand the insects by going out into the cosmos and studying how cosmic influences work into plant and animal, differentiating and spiritualising matter. Through these workings arise the infinite divisions of form which have effects on the insects right down to the most minute detail. Within the insect world we can observe most clearly"the deeds of light". But different insects show a falling back into a lower stage, that of the worm. This is overcome by metamorphosis and the creature is

transformed to a higher stage. The decadent insects of the lower types of insect show the counter effect.

The intimate connection of the insect world within the atmosphere, with all the cosmic influences working within it, with influences from the starry world leads us to an understanding of the insects. The insect world is the point where the lower Animal Kingdom comes to end in development. Nothing in the insect world can be found anatomically in Man. Nobody ever supposes that the insects have played an important part in the ancestry of mammals or of Man. The insects are an extreme branch of biological evolution.

But the forces which bring such development to the insects in material form work within the human being differently. In Man these forces are transformed into the soul and spiritual element. The forces which bring forth the insect world work within Man as thoughts and feelings. What happens within your head corresponds to something similar in a Bee-hive, only your head is filled with thoughts while the Bee-hive is material. The insect world is parallel to the soul world. All the while something is transformed from what would be a bodily element in the insect world into something in the soul element of Man.

A similar comparison may be made with the Birds, where what is bodily in the Birds corresponds to the thinking within Man."A man may have sparrow thoughts or he may have eagle thoughts".

Only intense and mobile thinking can lead us to understand the imago of the insects. The connection between plant and insect, which at first seems incomprehensible, becomes clear when seen from the standpoint of the spiritual. Only intense mobile thinking can bring us to an understanding that the insect world is intimately linked with the cosmos.

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EUGEN KOLISKO, one of Rudolf Steiner's most distinguished pupils, was educated at Vienna University as a doctor of medicine. He was also an authority on the Natural Sciences and History, and was a born teacher. As a lecturer in medicine, zoology, chemistry and history, he was much in demand, both in Europe and America. He died in London in 1939, at the age of 46.

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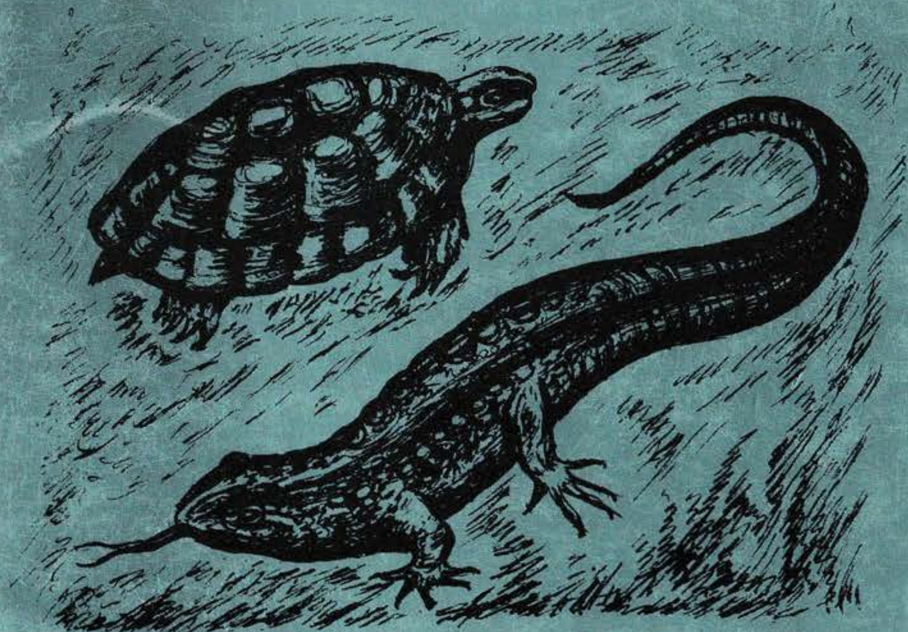
Amphibians & Reptiles



EUGEN KOLISKO

ZOOLOGY FOR EVERYBODY

A Series of Lectures

by

Eugen Kolisko
(M.D. Vienna)

12th Lecture
Amphibians and Reptiles

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Introductory Note

Dr. Kolisko intended to write a book on Zoology incorporating the material contained in his series of lectures given in 1932. This was not accomplished in his brief life.

Soon after his death, Mrs Lilly Kolisko published the first two lectures. In 1944 she suggested sketches which might illustrate Lectures 3 and 4, on the Mammals, which we published in 1979.

In 1980, with the help of Gladys Knapp, we were able to publish a further volume on the Protozoa – Zoology for Everybody No. 4; in 1981 volumes five and six were produced – Coelenterates and Echinoderms, Tunicates and Molluscs.

Now in 1985 we are publishing the final two lectures – Zoology No. 7 on Insects and this booklet on Amphibians and Reptiles.

We are again greatly in Gladys Knapp's debt for her continued efforts in translating and sketching the material for this series.

A. Clunies-Ross. Bournemouth, July 1985

List of Illustrations

ZOOLOGY FOR EVERYBODY LECTURE 12

AMPHIBIANS AND REPTILES

Amphibians

Our topic for today is the group of animals known as the **Amphibians**, and we will also consider the creeping creatures called the **Reptiles**.

May I remind you of the different animal types we have studied so far? First there were the great groups of the lower animal kingdom. Here we first spoke of the unicellular Protozoa. Then we studied the Coelenterates: the hollow creatures. These were followed by the Echinoderms: the Starfish and its relatives. Our next study was of those strange creatures, the Tunicates. We followed these with the Cuttlefish, of which we said that these animals developed, more or less, only the **head** formation. We continued with the other Molluscs. Then we spoke of the Worms; then the Insects, and then of the Fishes. Of this latter group: the Fishes, we said that they developed the **trunk** formation.

In earlier lectures we have considered the higher animals: the Birds and the Mammals.

Today I should like to speak of groups which come between the lower and the higher animals, with which we have dealt so far. These omitted groups are the Amphibians and the Reptiles.

Until the latter part of the nineteenth century, Amphibians and Reptiles were classified as a single group. There are certain ways in which the two types of animals resemble each other, but in other respects they are quite different. Nowadays they are classified as two distinct groups.

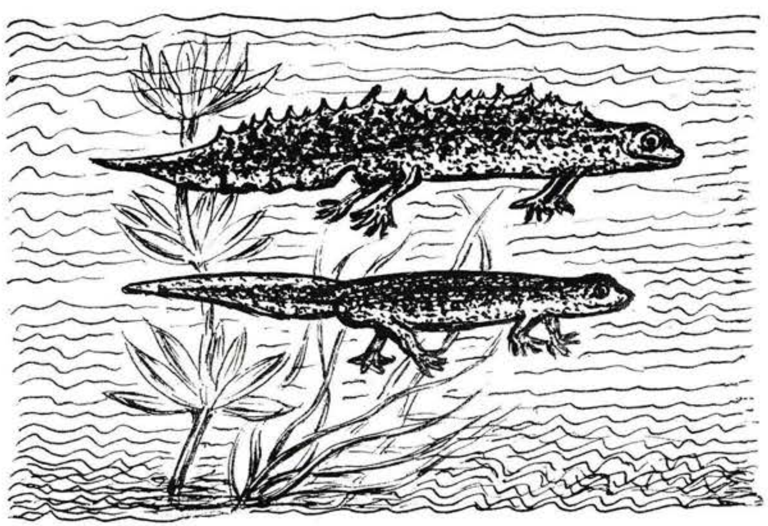

Fig. 1 Smooth Newt (Triturus vulgaris). Up to 11 cm. long.
Male and Female – most common in Europe.

The Amphibians are the first group of creatures to develop true **limbs**; a great advance in animal evolution. Amphibians have an endoskeleton, that is an internal skeleton, as well as limbs. The fishes have an endoskeleton, but no limbs. The Insects and other Arthropoda have limbs, but they are not true limbs like those the Amphibians develop. The Amphibians are a kind of preparation for that which appears in the higher animal kingdom.

Another characteristic of the Amphibians is that these creatures spend the early part of their lives in water; they then leave the water, and change over to life on dry land. From this characteristic they get their name: the "Amphibia", which means "both lives".

Because of the change of habit from water to land, the Amphibians undergo many transformations. Early in life they breathe through gills.

They transform their breathing systems after a while, and develop lungs instead of the gills they had earlier. With this change the whole metabolism of the creature is altered completely.

The frog is the most characteristic animal of this group. If we observe a frog, we can see that the skin is stiff and taut at the part within which is the skeleton. Enclosed within the skeleton is the lung, a bladder-shaped formation, which fills most of the space within the body. This is a most important part of the creature.

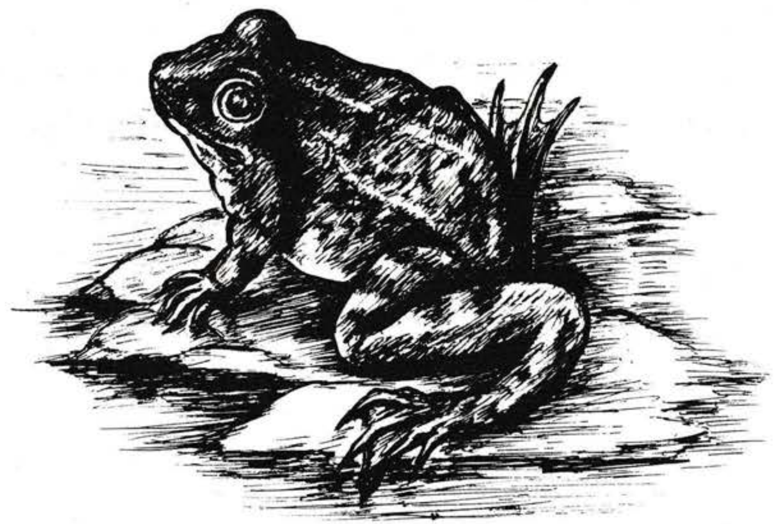

Fig. 2 Common Frog *(Rana temporaria)*

There is a very strong connection between the formation of the lungs and the formation of the limbs. It is the oxygen, which is inhaled by the lungs, which is used in the combustion process which causes the limbs to move. This is very obvious during the metamorphosis of a tadpole into a frog. The INVOLUTION of the **lungs** corresponds to the EVOLUTION of the **limbs**. In sketch 6 we can see how the tadpole organism with gills and no limbs is transformed into a frog with lungs and limbs.

The Amphibians are the first Vertebrates (backboned animals) to change from a life in water to a life on solid ground. As they adapt to life in the air, the Amphibians develop the faculty of producing sound. They acquire **voice**, **smell**, and **hearing**.

The fish, which spends its whole life within the watery element, is deaf and mute. As the frog develops, it hears and it croaks.

Furthermore, in fishes, reproduction takes place completely outside the individual creature. Eggs, and the sperm with which they are fertilised, meet in the water. It is the sun which provides the warmth for the development of the young of the fish. In the Amphibians, reproduction takes place through two individual creatures, in a primitive form of copulation.

There are other members of the Amphibians besides the frog of course. There are several species of Toads, many kinds of Newts and various kinds of Salamanders.

The skins of all these creatures are very remarkable. They are soft, not scaly and armoured, as is the case in the Reptiles. The skins of the Amphibians are damp and slimy. They are covered with small wart-like protuberances which are glandular; these emit excretions, which cause the skin to feel moist and slimy. The skin is very important to the Amphibians and serves many different purposes. To the frog, the skin is more important than the lung as a breathing organ. If the air is somehow excluded from the lung, the frog can still exist by breathing through its skin. But, if the frog's lung is functioning normally, whilst its skin is damaged, or prevented from obtaining air, the frog suffocates.

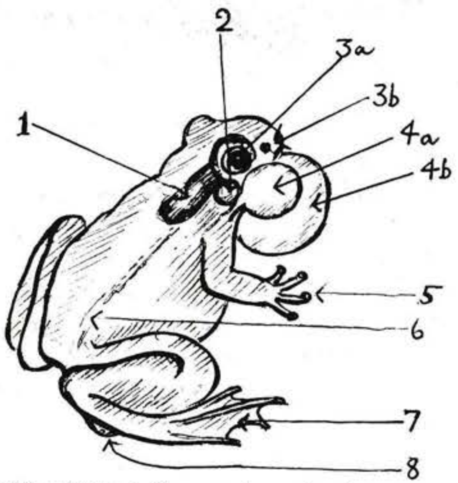

Fig. 3 Diagram of Amphibian tailless creatures showing some external features:-

1. Paratoid gland 2. Tympanum (hearing organ) 3a. Eye
3b. Nostril 4a. Vocal sac at side of mouth in some species, or
4b. Vocal sac beneath throat in some species. 5. Sometimes pads on finger tips
6. Dorsolateral fold 7. Webbing on hind feet
8. "Spade", an enlarged metatarsal tubercle used as a digging tool by Spadefoot Toads.

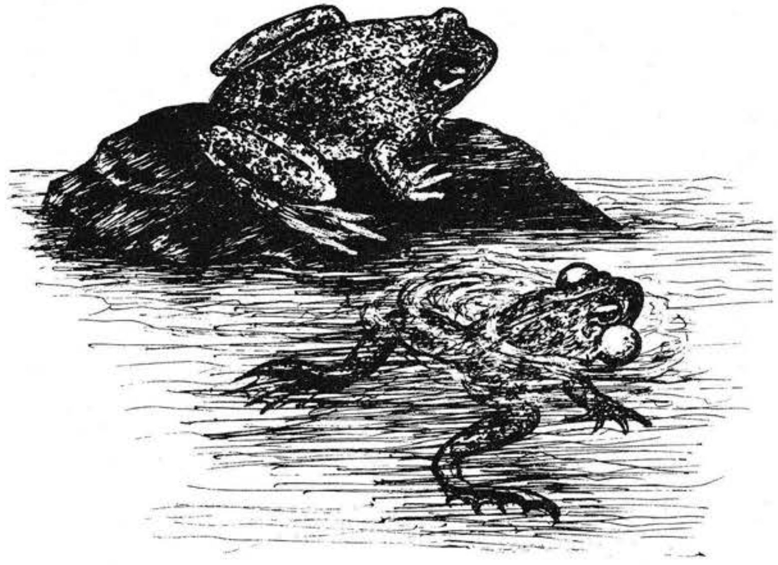

Fig. 4 Pool Frog *(Rana lessonae)*

The lower frog, in water, is a male showing inflated vocal sacs; these frogs are aquatic and noisy, croaking when in water.

The frog can live from ten to twenty days without having access to water for drinking, provided it is in a damp atmosphere. Frogs drink very little, usually absorbing moisture through the skin. Lack of moisture for some time may cause a frog to become very thin, but if it is put on a damp cloth it will recover its normal shape by absorbing water through the skin. The breathing process is very different from that of the higher Vertebrate animals.

Since the skins of the Amphibians secrete lymph-like fluids, all these animals develop poisons which can be more or less harmful to other creatures. The secretions from the backs of Amphibians are more potent, more similar to snake poison, than the secretions from the undersides of their bodies. Toad lymph can be especially injurious. If, for example, sand, previously in the surroundings of the toad, is put into a bird cage, the poisonous effect of toad secretions may cause the bird to die.

The Amphibians have skins of many different colours. The frogs are mostly greenish in colour; the many varieties of toads are mostly brownish. The Salamander has strong red and yellow hues, with black

Newts are usually greenish with yellow, orange or reddish tints. But whatever the colour, the skins of the Amphibians are always soft and glandular. Their soft bodies may give the impression that they are Molluscs. But the Amphibians have skeletons; the Molluscs have not.

None of the Amphibians are animals of the daylight; they all prefer dim light or twilight. They are all very sensitive to atmospheric conditions, to the light intensity and also to the humidity of the air. Because of this, their behaviour is sometimes used for predicting weather conditions. The frog, being very sensitive to moisture, is therefore considered a weather-prophet!

The frog is especially responsive to the humidity of the atmosphere when it emerges from the water for the first time. Amphibians have the peculiarity that their development goes through two distinct stages, firstly in the water and then on dry land. The first stage is similar to that of a fish, the second to that of a land animal.

In sketch 6 the different stages of a frog's development are shown. First there is the frog spawn: the eggs. This forms a slimy mass in the water. In

Fig. 5 Common Toad *(Bufo bufo)* with warty skin.
It normally walks, but hops when alarmed. The paratoid glands are obvious.

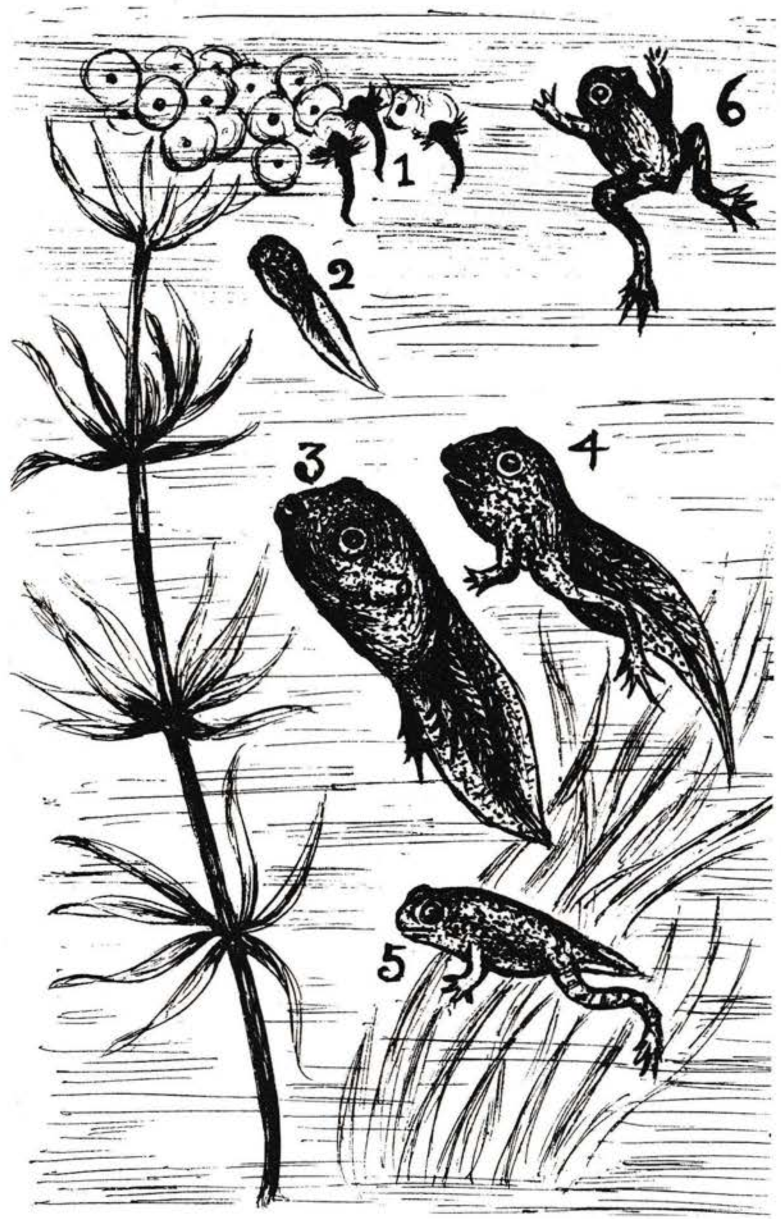

Fig. 6 Egg – Tadpole – Frog

each of the transparent, jelly-like eggs,there is already a tiny embryo. The embryo emerges and grows quickly; it is called a tadpole at this stage (No.1). The tadpole is a strange creature; it has a tail and appendages on each side of its head. These are the gills which are plant-like in appearance, and are the breathing organs of the tadpole. The tadpole looks very much like a fish (No.2) with its long tail and the gills. In the next stage (No.3) the tadpole seems to have inflated itself; this is because the lung is beginning to form. We notice at this stage that tiny legs are beginning to appear, first the back ones. Later (No.4) the pair of front legs are emerging as well. In No.5 the tail is shrivelling up, and in No.6 the tadpole is more compact in form, and is soon completing its metamorphosis. Shortly it will jump out of the water as a tiny frog, and begin its life on land.

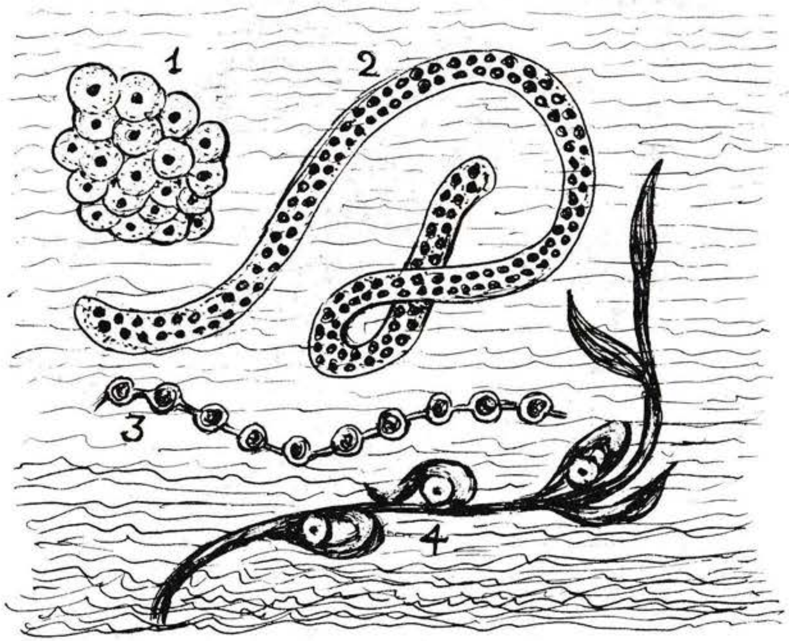

Fig. 7 Eggs of some Amphibians.

1. Typical Frogs. 2. Typical Toads. 3. Midwife Toad.
4. Newt's eggs on waterweed.
All have gelatinous coverings and are laid in water.

Fig. 8 Natterjack Toad *(Bufo calamito)* – 7cm. long.
Smaller than Common Toad, recognised by yellow stripe on back.
Walks or runs, rather than hops. Found in sandy coastal areas, with back legs shorter than those of the Common Toad.

Everything is changed as the frog is transformed from a water-creature to one living on solid ground. The lung develops, which means that the animal must breathe more deeply. The reaction to this deeper breathing is that the limbs develop.

In the Insects, as the trachea-system develops for breathing purposes, the reaction is the formation of the tiny spider-like legs. These limbs develop as the trachea-system is forming. Movement is produced as a result of the breathing in of oxygen. The lung forms as the limbs develop, so that creatures may live and move on the dry soil. The inner forming of the lungs is connected with outer forming of the limbs. The two processes take place simultaneously.

It is not surprising to find that if human beings develop some illness of the lungs, the type and condition of the soil in the place where they live is of great importance to them. Whether the person concerned lives on a limestone soil, or on a soil with a high silica content, has an influence on the lungs.

Whilst an amphibious creature is living in water, it is separated from earth; but as soon as it has a lung it stands on the earth. We can see how a frog distends itself while making the effort to form a lung; a sac-like bladder is formed. In this process, the frog gets shorter; it draws itself together. A balance has to be created to compensate for the lung formation; the result is that the limbs are produced. The length of the hind legs corresponds to the lung formation in the front of the body. We can see how these processes are connected. In Nature, whenever there is metamorphosis, there is always a tendency for a balance to be produced. Goethe called this the "law of balancing the budget."

The snake is long and has no limbs. The fish, too, is long and also has no limbs. The frog is short; everything is drawn together; the limbs appear. The frog has a short spine compared with that of a fish. The frog has an enormous head, a big mouth; and below are the legs and in the centre the large lung sac. We feel that the frog would always like to inflate itself, to puff itself out to the size of a Bullfrog, as fables often describe. The air element within it works too strongly; that can make the creature shapeless. The frog is too sensitive to the air, and especially so in its legs.

The Amphibians may be described as complete contrasts to the fishes of deep seas. Fish-like creatures living in the depths, near the ocean beds, transform their muscles so that the muscle substance shrivels, and becomes nerve substance. Such vertebrates as the various Rays, which are found in the depths of warm oceans, are creatures of this type. They can emit electricity. Ray-fish can give powerful electric shocks, for defensive purposes and also when killing prey. Whereas the Ray can give electric shocks, the frog reacts in the opposite way. It does not give electric shocks but receives them. The Ray delivers blows; the frog does not deliver blows, but reacts as if receiving them. If there is the slightest movement near a frog, the creature leaps with its long hinged back legs. It reacts very quickly, and is therefore often used as the best object for physiological experiments. Everything about the frog twitches; the frog is so mobile. There is electricity in the atmosphere, and the frog is the best medium for demonstrating this. The minimum amount of electricity produces a reaction in the frog.

The flesh of the frog's leg is very soft and delicate, and it is extremely sensitive. Why is this? The frog is the animal in which, for the first time,proper legs have been created. These delicate legs respond to the slightest stimulus in the air around, and they are very mobile. As the air enters the frog, for the very first time, the astral element within it reacts strongly. Sensation leads to movement.

The limb system of the frog is the centre from which movement and action proceed. If the brain of a frog is damaged, the creature can still move and even jump about. In contrast to this, if the brain of a human being is only very slightly injured, then the person is handicapped as a result. Not so the frog. As far as movement and action is concerned, it lives completely in its hinged legs. The head of the frog is unimportant, as far

as movement is concerned. It is the legs and the lungs which are the interesting and important parts for this purpose.

Even when amphibious creatures are dead, they can still react to outside conditions for some time. We might describe these animals as being "too much alive"; they are too lively. This is a characteristic of amphibians, which emerge from the watery element, and come into contact with the air for the first time. The effect of this is very pronounced.

Fish are adapted to a life within water, and they become immobile when they leave the watery element. The frog responds in the opposite way when it leaves the water, and comes on to land and into the element of air. This is the way air affects living creatures. The frog comes out of the watery element and catches insects. It uses its tongue like a club, and flicks it out, strikes, and draws insects into its mouth.

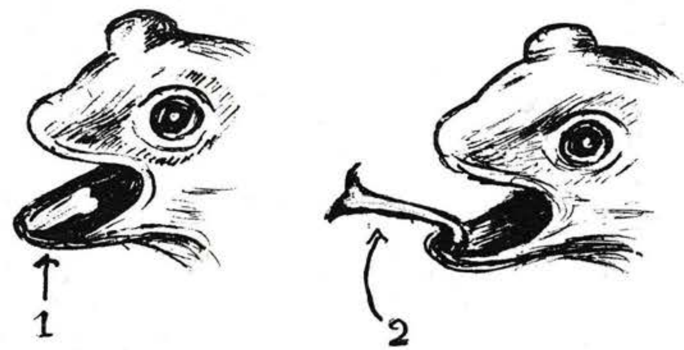

Fig. 9 Tongue of Frog

The Frog flicks out its long tongue to catch insects.

There is no other animal which looks like a frog. Its bodily substance has an elastic quality, which can be stretched indefinitely. It is the airy element which causes the unusual and strange mobility of the frog.

If we study the bone structure of an amphibian, we find that the spine is very short. The hind legs are longer and more developed than the front legs. The fore-limbs are terminated with something like a hand. This characteristic is more pronounced in the Salamander, where the limbs really grow out of the creature. We can also observe this in the Lizards. We feel that the limb formations of the amphibians lack a certain perfection; they seem unfinished and incomplete. The muscular system is

Fig. 10 Fire Salamander *(Salamandra salamandra)* – 20-29cm. long.

Found in warmer parts of Europe, also in Africa and South West Asia, Large paratoid gland. Much variation in pattern; usually in brilliant yellow and black stripes, or black with yellow or orange spots. Moist skin.

extremely excitable. The nervous system is more developed than that of the fishes; the brain is larger. The breathing system has developed the lung. It is interesting to observe that the fish has really got a lung, although it is not used as such, but it is used as an air-bladder. The amphibious animals transform the air-bladder, which they no longer need for swimming when they leave the water, and as they come into the airy element it becomes a lung.

The circulatory system is also transformed. The heart of an Amphibian is not like that of a fish. The blood of a fish is purely venous; in the heart of the fish there are two chambers, which are separate, out of which the blood flows. The heart of the amphibian changes considerably as it develops a lung instead of gills; as it changes its habitat from water to land. A special auricle is developed on the left, and in this side the aerated blood from the lungs is collected. The ventricle is not divided, but the arrangement is such that a large proportion of aerated blood from the lungs passes to the head, while most of the oxygen-poor, venous blood from the rest of the body passes to the lung arteries. Thus the amphibian heart is more developed than that of the fish, but the circulatory system is still imperfect.

The hearts of birds and mammals are much more complex. The venous blood, returning from the body, is collected in the right auricle, and thence to the left ventricle. The lung veins return the blood to the left

auricle, and goes thence to the left ventricle, which passes the blood to the body tissues. Thus the circulatory systems of mammals and birds are much more developed than those of the amphibians. Birds and mammals are warm-blooded creatures.

In the human being the blood-circulation is cross-shaped. If in Man a dividing wall did not exist in the heart, the venous and arterial blood would mix.

We observe that there is a development in the circulatory systems from fish to amphibians. The fish has purely venous blood. The Amphibian has circulation of mixed blood. Moreover the amphibian circulatory systems adapt from that of gills and tail to the wider form of lungs and limbs. The blood of the Amphibians is not yet warm. Warm blood has not yet been achieved by them.

The Amphibians have also developed further than the fishes in other ways: in the digestive system, and also in the sense organs, which are quite different. In the fishes the various senses are spread out over the whole organism.

The organs of smell and hearing are close together in the head of the Amphibians (sketch 3). When the frog croaks, the sound bladders, the vocal sacs, expand on both sides (sketch 4). The sound organ is placed rather clumsily; the sound is **forced out**. What the frog says with its wide mouth is interesting; it is just "Croak! Croak! Croak!" What works itself out, when organs from the water come into the air for the first time is very primitive.

It is interesting that most people have a strange feeling of revulsion about Amphibians and Reptiles. Although these creatures are much more highly developed than the Fishes, we cannot help having contradictory feelings about them. Our feelings concerning the frog are not so strongly antagonistic. But we feel that there is something weird and uncanny about their near relatives; the toads and salamanders. With the lizards and snakes the feelings are still more pronounced. We cannot help being repelled. It is a naive, instinctive feeling.

Many fables tell of these dragon-like creatures. Why do we have feelings of revulsion for these creatures? It is because of their earlier history.

The reproduction process in the Amphibians is quite different from that of all the lower animals, and also from that of the Fishes. The entry of the air element into Amphibians has a reaction in movement and sensation. The reproductive process is drawn into the interior of the animal. In the Fish the eggs are laid in the water and fertilisation takes place without any contact between individual fish. The Amphibians are much more involved in the mating process. Some Amphibians take care of their young. The so called Midwife Toad wraps the egg-cord around itself and carries it around, helping to develop the young ones.

There are two main groups among the Amphibians: those with a tail and those without. The latter include various species of frogs and the many varieties of toads. The Amphibians with tails are the Salamanders and the Newts. They stay nearer to the fish stage than the frogs and toads, but they do develop a lung. They have only short, hand-shaped limbs, and remain nearer to the life in the water. We find a tendency towards one or other of these two groups in all the Amphibians. Some Newts do not develop further than the tadpole stage.

One of these Newts is the Grotto Olm. It lives in the damp underground caverns in the limestone Karst* regions of South East Europe. It is a strange Newt. It has eyes, but cannot see with them. It is white with a slightly reddish tinge; the colour is similar to that of the human skin. People in South-east Europe call it, "the little Man-fish." It

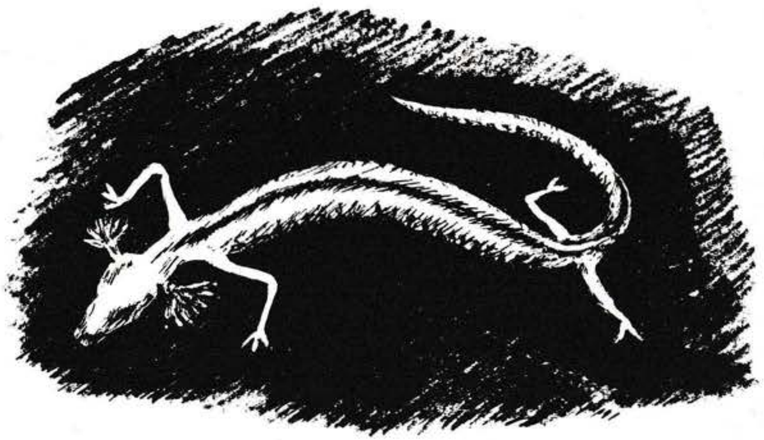

Fig. 11 Olm *(Proteus anguinus)* – 20-25cm.

The strange newt-like creature which lives in the subterranean caverns of the limestone Karst areas in South East Europe. It is colourless except for pink gills, and remains at a tadpole stage all its life.

* **KARST** – A limestone area in S.E. Europe, with typical limestone features such as underground streams and limestone caverns.

looks somewhat like a salamander, and has a pointed, cone-shaped head. It has gill appendages throughout its life, and is at a lower stage of development than most Newts. Professor Kammer, a Zoologist of Vienna took some very young Olms and put them in a place with red light. When they were used to this, he brought them into stronger light, and he found that they developed eyes with which they could see.

There are other species of Newts which keep gills all their lives and never develop a lung. They remain at the tadpole stage all their lives. In the whole Amphibian group there is a possibility of metamorphosis either towards the frog stage or towards a permanent tadpole form. It is possible to find all forms of transition between the two extremes among the Amphibians.

—★—

Reptiles

These animals are so called because they all have crawling movements; the name is derived from the Latin "repto", meaning "creeping; grovelling."

The Reptiles include the Tortoise (the land-dwelling Tortoise, the semi-aquatic Terrapin, and the marine species, the Turtles); the numerous kinds of Lizards; the many Snakes and also Crocodiles.

The skins of these animals are not moist like those of the, Amphibians, but scaly or armoured. The Tortoises have a skin which is mainly armoured. The skins of the snakes are of scales. The Crocodile has a tough armoured skin which is different from the other types. The various species of Lizards have skins of different colours, many very beautiful. The Snakes have very interesting patterns on their skins, which are frequently colourful; so, too, are the coverings of the tortoises.

The Reptiles are distinguished from the Amphibians by having lungs from the beginning of life. They do not undergo transformations, as the Amphibians do, for they do not make the change from life in the watery element, to life on dry land. The young of the Reptiles are hatched out from eggs, laid on land. Apart from the snakes, the reptiles have limbs. Snakes, too, have limbs during the embryonic stages, but these are lost as they develop towards maturity. Reptiles have lungs and limbs, and they do not pass through a fish-like stage in their development. The

Professor Kammer, a Zoologist of Vienna University in the early decades of the 20th Century.

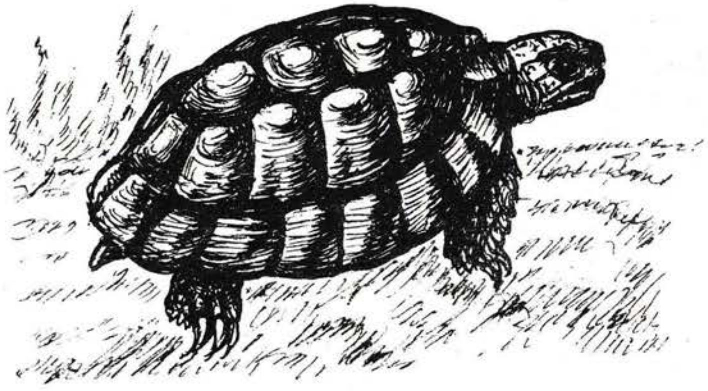

Fig. 12 Tortoise *(Testudo hermanni)*

Reptile with a shell, which consists of a carapace above and a plastron beneath.
Lives in warm, dry habitats.
The young are hatched from white hard-shelled eggs.

Amphibians still alternate between fish and land animals, swaying to and fro between water and land, as it were. The reptiles have made the decision to be land-dwellers, but they still have a strong connection with the watery element.

The blood circulation of the Reptiles is different from that of the Amphibians. Whereas the Amphibians develop three chambers of the heart, for instance, the Reptiles develop four. But though apparently more developed, the circulatory system of the Reptiles is such that the aerated and non-aerated blood is to some extent mixed. Therefore their blood fluctuates in temperature, and is alternately cool and warm. The temperature of the reptiles still depends on the temperature of the surroundings. Thus reptiles are not warm-blooded like the birds and mammals. Reptiles love to bask in the warmth of the sunshine. Snakes, Lizards and Crocodiles love the warmth of the sun.

The Amphibians are quite different in this respect. They prefer the twilight and love a damp habitat. Reptiles like to have dry surroundings. Snakes and Crocodiles lay eggs, mostly with shells of lime, as the birds do. The reptiles have many characteristics in common with those of the birds.

The Snake is the most representative creature of the Reptiles. It is remarkable to observe how the limbs of the snake disappear as the embryo develops. The Snake, having developed limbs, then loses them, and in this and other ways shows signs of decadence.

The skeleton of the snake is also strange. The creature has ribs, numerous ribs; no true limbs; and a very small head in proportion to the rest of its body. Why is this? A snake looks likes a worm, but from its skeleton we see that it has a backbone; it is a vertebrate, not a worm. It unites worm-like characteristics with certain qualities of a Vertebrate animal. Furthermore a snake has a large stomach and large intestines; these give it the possibility of devouring and digesting a huge quantity of food. The skin on the back of the snake, the part which is decorated with a pattern, can stretch and expand when necessary, during the digestion of an unusually large meal. This strange creature, the snake, combines the characteristic of a vertebrate and of a worm (which is merely a digestive tube). The Vertebrate and the worm are therefore combined in one creature!

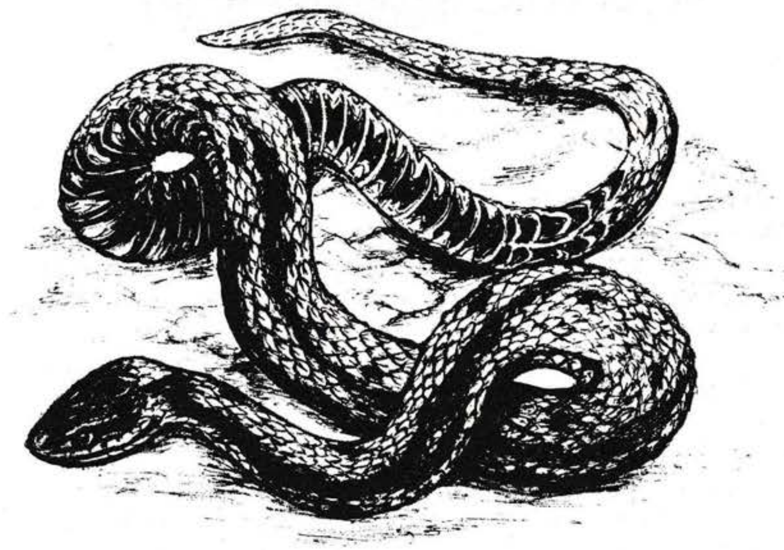

Fig. 13 Grass Snake *(Natrix natrix)*

The Snake has lungs. Usually the left lung has deteriorated, while the right lung grows very long and reaches to the stomach. Many of the other reptiles have lungs like this, with the right lung much more strongly developed than the left. There are also many variations.

We have already mentioned that the snake has a small head. This shows a deterioration. The frog's head is well developed. The snake has lost its limbs and it has also lost its voice. Nothing remains of the voice except a hissing sound. The lung of the snake has become exceedingly long; of its voice only something consonantal remains: only the S sound, which is an expression of the creature itself.

Fig. 14 Eggs and Young of Grass Snake.
Eggs are whitish-yellow, about one inch long, soft and rather sticky and are laid on the ground.

We have a strange feeling that the snake, in earlier times, had a more highly developed organism. We feel that it has fallen back from what it once was in past times, to a more lowly stage of development. The snake creeps about like a worm. It ought to have limbs, but the only part of the snake which acts like a limb is the tongue.

It is remarkable how the snake instead of developing a compact organism with its backbone, has produced such a long, narrow body. It has lost its limb system. Therefore it has no voice.

The reptiles have much in common with the birds. But there are also distinct contrasts between the two groups. Birds have very well developed voices. If we compare a bird and a snake, we observe obvious contrasts. The bird has a limb system, and its whole organism is penetrated with a musical quality. All that remains of the snakes voice, on the other hand, is a hissing sound. Yet the snake is very sensitive and very responsive to music. It may even lose the discretion it usually possesses and become fascinated by musical sounds. Hence the power which snake charmers exert over some reptiles.

Another interesting fact is how crocodiles like to live among birds. We hear stories of how the long-legged birds, Cranes, alight on the backs of

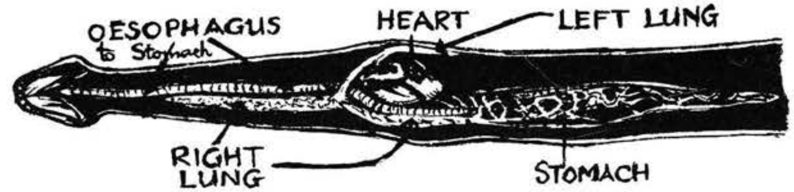

Fig. 15 Section through front part of snake.

crocodiles and clean them up! Cranes and crocodiles live together in harmony. Whatever quality one of them lacks, the other possesses. The Crane flies down from above and alights on the huge reptile, the crocodile. This is a case of symbiosis. Wherever we find a case of symbiosis in nature we must always ask, "Why does this happen?" The answer is that always the two creatures or plants concerned are complementary to each other; that is, one has what the other lacks. Each searches for its opposite, and yet the two must be complementary to each other. Although symbiosis* works in a positive way for the two entities concerned, yet there is always something like hostility between them; they work for each other, but also against each other in a negative sense. The Sea Anemone and the Hermit Crab are another pair of creatures which provide an interesting example of symbiosis. We must always consider the whole organisation and relationship of the two entities to find an explanation of symbiosis.

The intense vitality of the blood of the reptiles, goes into the teeth of the poisonous snakes. Strong muscles surround the poison glands in the snake's head and conduct the poison to the tooth. The intense poison acts very destructively on the human blood. As we have said before the snake is a very strange creature, and we can see from its organism that it has become degenerate in many ways.

There is so much which could be said about the Reptiles and the Amphibians. It is interesting that not many species live in the more northern regions of the earth. In Europe the poisonous Adder is found, but it becomes more rare as we move north, and it is not found in Ireland. It is the same with the Amphibians and other types of Reptiles; they

***SYMBIOSIS** - A definition used in Biology (from Greek meaning "living together"). Symbiosis - a permanent union between two living organisms, each of which depends on the other for its existense. Example: Lichen - is an Algae and a Fungus living in close combination.

become more and more rare the further north we go. In the tropics both Reptiles and Amphibians are found in great variety and in large numbers.

Another interesting fact is that the Snake has the force, which is **not** in its limbs but in its eyes. The Toad also has the power in its eyes, but not so strongly as the snake. There is poison oozing out from the skins of these creatures. There is poison in the Adder's teeth and there is also poison in the **looks** of amphibians and reptiles. The snakes especially have a rigid look in their eyes.

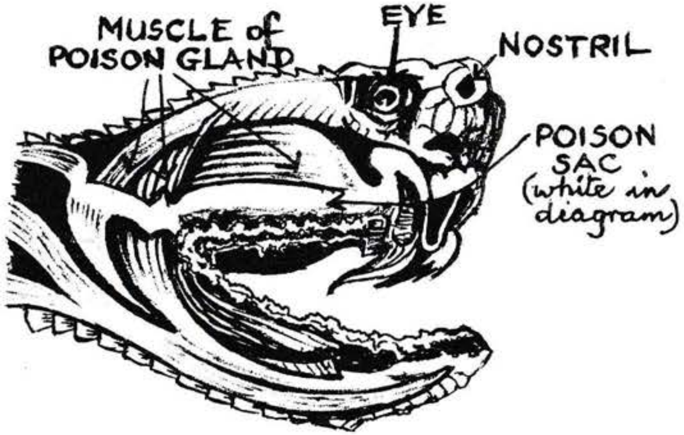

Fig. 16 Diagram showing section through Head of Poisonous Snake.

We know that the snake was a more highly developed creature in the past; it has lost certain qualities it once had. The mobility which was once in the limbs of the snake has entered as a force into its tongue and teeth. There is a strange, uncanny relationship between Man and the Snake. We can observe this in the way a Snake Charmer influences a snake.

Rousseau, the 18th century Frenchman, used to hypnotize toads. He found that as he gazed at them they became quite rigid. But on one occasion he had a very unpleasent experience. He was not feeling very well, and when he tried to hypnotize a toad, he found that the opposite happened! He himself became rigid and fell down. The will organisation is very strong in amphibians and reptiles. There is an interplay between Man and Animal. We have the strange feeling that the Reptiles and Amphibians have a link with the human will organisation. Most human beings have an instinctive revulsion for amphibians and reptiles. This can

be explained by the fact that our moral and intellectual development has been accomplished in opposition to those forces of vitality which are developed in a one-sided way in the Amphibians and Reptiles.

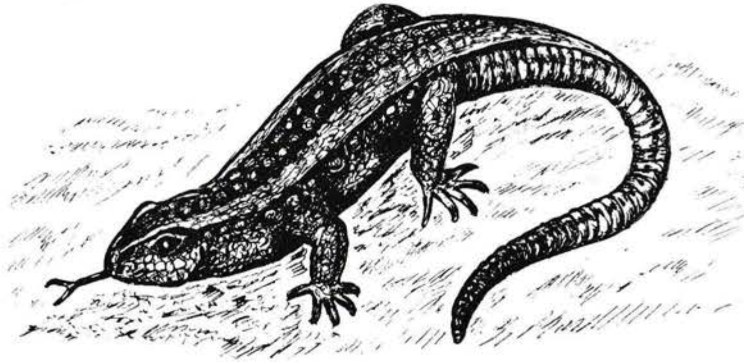

Fig. 17 Sand Lizard *(Lacerta agilis)* – 18cm. long.
Lives on sand dunes in southern Britain. Lizards have scaly skins.

To summarise then, there are three types among the Reptiles:

The Lizards
The Snakes
The Crocodiles

The Lizards have the highest development of the nerves and senses among the present day reptiles.

The Snakes are the most typical of the Reptiles: they have the digestive system well developed.

The Crocodiles have developed the digestive and limb system especially.

All the Reptiles are really dwarf remainders of the great Saurian monsters of Mesozoic times.

Present day Amphibians and Reptiles are miniature creatures in comparison with the huge Saurians. They are the only representatives of that monstrous animal kingdom which was in existence before the world of Mammals, Birds and Fishes came into being.

It is especially in India, the Malayan Archipelago and neighbouring regions, formerly around the ancient Lemurian Continent, that we find the Lizard types still in existence at the present time. There are flying lizards, flying dragons and all sorts of creatures such as the Iguana and Leguna which are images in miniature of the former great Saurians.

The Chameleon, too,is a strange lizard-like creature, which represents something which was formerly much more developed. It changes its colour, a phenomenon which is connected with a state of excitement. This is a development in the Reptile group towards progress in the nerve-sense system.

The Snake develops the digestive system especially.

The Crocodile is the most powerful and voracious of the Reptiles still in existence. The lower part of its body has become very coarsened. Its teeth are very strong and powerful. The Crocodile's nature shows a special relationship to that of the ancient Saurians.

The Lizard is the highest type among the Reptiles; the Crocodile is the lowest.

The Tortoises, with their remarkable shell-like coverings, are an interesting type among the reptiles. We can observe that a tortoise is really completely imprisoned in its armour; only its head emerges, just as a snail looks out from its shell. The Tortoise is a "snail" at a higher stage of development. From the cumbersome body, what a miserable little head protrudes! Both the tortoise and the snail are distinguished by their slowness. The slowness of the snail and of the tortoise are proverbial! The Tortoise has certain links with the Amphibians. Both among the Amphibians and the Reptiles we find examples of metamorphosis towards one group or another; there are many examples of transitions.

Let us look back to the time in the evolution of the earth before the great Saurians became extinct. In these very ancient times there were three main dragon-like types in existence.

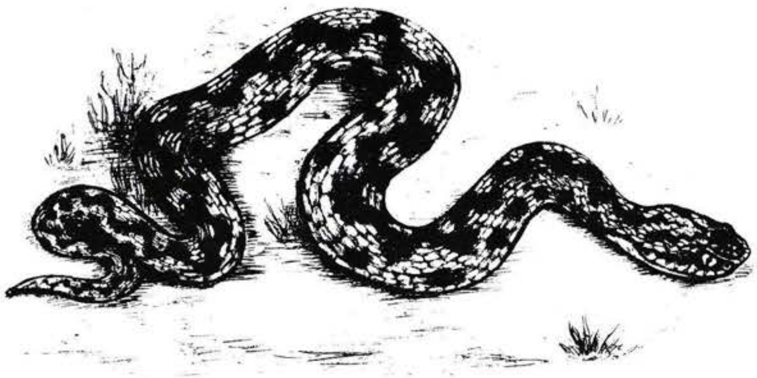

Fig. 18 Adder, Viper *(Vipera herus)*
The most common British snake and the only poisonous one.

The Plesiosaurus was a massive creature, somewhat like a hippopotamus in some ways. But its limbs were like huge fins or paddles, which suggests that it lived in swampy surroundings. This animal had a long neck like a giraffe and a small head.

The Ichthyosaurians were more fish-like in type. They were like creatures which nowadays live in the ocean depths.

Then there were the flying Saurians, which travelled with a paddling, rather than a flying movement, for the air at that time was very much denser than our atmosphere is at present. All creatures of the Saurian epoch had huge eyes, for the Sun's light did not penetrate the dense, misty air.

Then came the time when the whole of the Saurian animal kingdom was destroyed, as the strange, swampy earth underwent profound changes. The Saurians could no longer exist in the changed environment.

Popplebaum, in his book "Man and Animal" describes how this great transformation in the evolution of the earth took place. Man had not yet appeared on the earth. There were no human beings in the world at the time of the Saurians. The whole earth and its surroundings underwent profound transformations. The atmosphere cleared. The earth became solid ground. The world of the Saurians disappeared. These monstrous creatures were exterminated. Birds appeared; so did Mammals. Flowering plants came at the same time.

In the chasm left by the disappearance of the great Dragon-like Saurians, the five great Phyla of the Vertebrates appeared.

Birds
Mammals

Saurians ----- Reptiles
Amphibians
Fishes

In the Stuttgart Museum, there is a very fine collection of specimens from the Jurassic Period. Here we can observe the immense size and the powerful organisms of the extinct Saurians. In this Museum there are the remains of all kinds of strange, dragon-like creatures, none of which exist in the world today. Only a few types, much more refined and miniature in size, are to be found as representatives of the Saurians, at the present time, in the Reptilian Group. The massive Saurians disappeared from the earth.

In this Course of Lectures, we first dealt with Birds and Mammals, the Higher Animal Kingdom. We tried to show how Man and the higher animals belong to each other. Man unites within himself what each of the various animal types represents in a one-sided way.

After discussing the Birds and Mammals, we studied the Lower Animal Groups, starting with the unicellular Protozoa. We saw how the Coelenterates differentiated digestive and nerve substances. In some types the head system was developed, in others the body. It was the Fishes which formed the main trunk of the organism most perfectly. The Lower Animal Kingdom terminates with the Fishes.

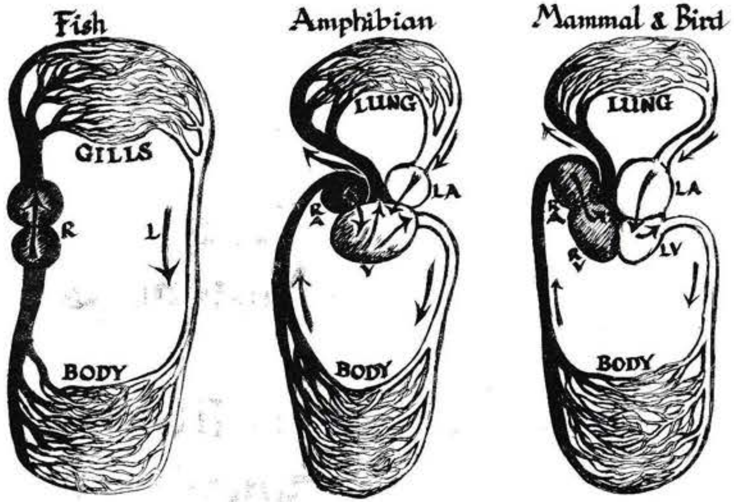

Fig. 19 Diagram Comparing Circulatory Systems of Fish, Amphibian, Mammal, Bird.

R – Right L – Left A – Auricle V – Ventricle.

After the Fishes, we saw how some creatures left the water and developed limbs. An attempt was made to form a circulatory system, to develop warm blood and a constant body temperature. But the attempt was not successful; the Saurians were discarded, thrown out of the evolutionary process.

So, between the Fishes and the Higher Animals, a great chasm appears in the evolutionary process.

Eventually, the most complete and perfect organism the animal kingdom was capable of achieving, was produced. Man appeared on the earth.

The Lower Animal Kingdom is linked with the development of the Cosmos; the Higher Animal Kingdom is more closely related to Man. Where the Higher and Lower Animal Kingdoms touch one another; there Man appears. All would not have come into being, had Man not been the cause.

We have now completed our studies of the twelve great groups or Phyla. We will deal with the relationships of the different groups to each other, and their connections with Man. We will speak of Man's links with the animal kingdom and with the cosmos. This will be the content of the two final lectures of this Course.

Note

Shortly before his death, Dr. Eugen Kolisko, wrote an article for Dr. W.J. Stein's "Present Age" which incorporated the content of the 2 final lectures of the Zoology Course.
This has been published as "The Twelve Groups of Animals".

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