MORE ENIGMAS
OF
NATURAL HISTORY

BY THE SAME AUTHOR

English Country

The Common Earth

Enigmas of Natural History

Etc., Etc.

MORE ENIGMAS OF NATURAL HISTORY

By E. L. Grant Watson

Illustrated by

BARBARA GREG

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Introduction

The following series of essays, the sequel to an earlier selection, contains further stories of animal life-histories and associations, which like all patterns of life when closely regarded must stir our wonder. In so far as our contemplation of Nature is creative, the pictures which reach us through our senses become ideas within our minds, and these constituting an inner world which memory can make more permanent than the passing kaleidoscope of outer events, lead the imagination to seek some possible co-ordinating principles which may give to such divergence a unity. The theories of science and the doctrines of religion are each the outcome of such co-ordination, and should be judged as valid in so far as they are in accordance with the facts they seek to explain.

The point of view which lies behind these essays is sceptical towards the general validity of the mechanistic interpretation of nature which is implicit and often explicit in the more generally accepted classical theories of evolution. The author does not believe that these offer an adequate basis of orientation for the patterns of life as they are revealed in the natural states of living things. The artificial amplifications or restrictions of the experimental laboratory are not in his opinion of such *ultimate* importance as the observation of behaviour in normal environment. That laboratory experiments can have an auxiliary use and function he does not question, but he would maintain that such experiments are often invalidated in their general implications, in that they are based on the assumption that the lives of animals and plants may be regarded in their entirety, in terms of physics and chemistry. The invisible counterpart, which he believes forms an essential portion of the organism, is seldom taken into account. By the very fact that the experimenter removes the creature from its natural background, he may be doing violence to the essential nature of that creature. In this way, a dog, isolated for a long time in a sound-proof room, and under the influence of a steady, unaltering light, is no longer an entire dog, any more than the experimenter himself would be in like circumstances an entire man. It has been changed into something else nearer to the mere mechanism that some scientists have tried to prove it to be.

The life-histories in this book tell of animals in their natural condition, and are written from the belief that the visible form and behaviour of animals is not their entire being, but that they are the visible manifestations of spiritual forces, as yet ungauged and unknown, though obviously creative and formative and capable of some measure of change. This belief postulates a world of non-material living beings in order to explain the creation in this world of new individuals; it further claims that many of the biological and psychological theories of the present day, in so far as they try to explain the phenomena of their sciences entirely in terms of physical matter, are trying to do what is impossible; and are in the same position that a mathematician would be in if he attempted to make an equation which involved three arbitrary constants passing through five arbitrary points. More terms have got to be put into the ideas before they can fit the facts.

Such contentions as these do not, of course, make any claim to be original, and they are only stated to show the background of thought which lies behind what are but partial pictures of the natural world as they appear to one observer. The essays are not written in any argumentative mood, but, taken as a whole, they contribute towards a definite point of view—one which is by no means isolated or unsupported. The late William Bateson is not the only biologist who has maintained that there must be some non-material substances acting on the germ-cell to cause its development. Many other naturalists have grown sceptical of the older, mechanistic theories. The belief in Animism, so much despised at one time, is now defended by quite reputable writers. William MacDougal has written: 'Animism (essentially the theory that the mind depends on other substances than the chemical molecules of the brain) recommends itself just because it points to a great unknown in which great discoveries await the intrepid explorer, a vast region at whose mysteries we can hardly guess, but which we may look forward to with wonder and awe, and towards which we may go on in a spirit of joyful adventure, confident in the knowledge that though superstition is old, science is still young and has hardly yet learnt to spread her wings and leave the solid ground of sense perception.'[1]

E. L. GRANT WATSON

[1] *Body and Mind; a History and Defense of Animism.*

Nurseries, Nurses and Midwives

That tadpoles, if developing in their natural surroundings, usually turn into frogs is a fact well known to any country-bred child, and we all know the great number of eggs that the mother frog is capable of producing. Anyone with but small powers of observation will have noticed how careless the frogs are in laying their eggs, how that they often lay in but shallow pools which are destined early to dry up, and where their eggs or the newly emerged tadpoles perish. The frogs which produce such immense numbers of progeny can afford to lose a large proportion of their offspring, secure in the fact that if but a comparative few survive, these few will be sufficient.

This prodigality and carelessness of habit is not however the rule with many other species of frogs, which appear to act with care and forethought for the well-being of their young, and which will make sheltered and adequate nurseries for their descendants, even though they do not stay to watch over their welfare. There is a tree frog, living in Brazil (*Hyla faber*), which protects its progeny by building basin-shaped nurseries in the shallow waters of the edges of ponds. The female frog scoops out the mud to the depth of three or four inches; with the mud she has removed from the bowl of the basin she builds a circular parapet, which rises above the surface of the water. She uses her webbed hands for smoothing the inside of the mud wall and her abdomen, which she flops up and down, for smoothing the bottom of the basin. These nurseries, spotted about the borders of ponds, look like the craters of tiny, extinct volcanoes, and measure nearly a foot each in diameter. In each of these nurseries the female frog lays a few eggs. The young tadpoles in their early stages are protected by the walls of the craters from the attacks of aquatic insects and fish. As the larvae grow older and larger, the walls of the nursery become gradually disintegrated by the action of wind and water, and the growing tadpoles escape to take their chances in the larger world of the pond.

Another frog, this time in Japan (*Rhacophorus schlegelii*), makes her nursery in a safer place and more distantly removed from the dangers of exposure. The male and the female together bury themselves in the damp earth on the edge of a ditch or stream, and there make an excavation placed at a few inches above the water level. They take some time and trouble in smoothing the walls of this chamber, and in doing so block up the entrance through which they have come. When they are completely enclosed in their smooth-walled retreat, the female produces from her vent a secretion, which by quick

movements of her feet she beats up into a froth of slime and air-bubbles. Into this she lays her eggs. The male who all this while has been clinging to her back, impregnates the eggs as they enter the slimy agglomeration. The pair then separate and make their way out of the marriage chamber, which is now destined to serve as a nursery for the young. They do not, however, go out the way they came in, namely upwards towards the surface of the ground, but they go downwards, obliquely towards the water of the stream. In this action they would *seem* to show great forethought for the welfare of their tadpoles, and would *seem* also to be governed by an understanding of direction. This tunnel which they now make is utilised later by the larvae, when the time is come when they shall escape from the safety of their nursery. When the eggs hatch, the tadpoles find themselves completely protected; they live in the frothy mass surrounding them, breathing the moist air-bubbles which are there entangled. By the time they are old enough to seek a wider sphere of activity, the froth and bubbles of the original nest have broken down into a kind of slime, which assists them to slither down the tunnel into the stream.

A similar nest, made of froth, is used by several other species of frogs as a safe harbourage for their young. Tree frogs in South America often attach their nests to leaves, which by the slime are held together. Such nests are usually made over pools of water. When the eggs hatch, the young tadpoles wriggle about in the protecting agglomeration of air-bubbles and slime. When they are older, they drop off the trees into the pools beneath, and in the water finish their metamorphosis in the usual way. The eggs of these tree frogs, that make nests or nurseries, are far fewer than those of the more careless species, and they are also much richer in yolk. More of substance can be given to them, since their survival-chance is greater.

Another form of nursery into which are introduced only about a dozen eggs is made by a New Guinea species of frog (*Phrynixalus biroi*). In this case the eggs are enclosed in a transparent membrane secreted by the mother. This capsule lies in water while the development of the young takes place within the egg. No free tadpole stage has been observed, the young tadpoles lying curled up within the eggs, breathing through their tails, and without any normal development of gills. This breathing through the tail is not an uncommon habit amongst the tadpoles of tree frogs. Several different species in different parts of the world develop within the egg and use their tails as breathing organs.

The habit of making nurseries and then abandoning them and their contained nurslings to chance is one method followed by a fairly large section of the frog population of the world. Other species, instead of making nurseries, become themselves the nurses of their broods. There is a small South American frog (*Denerobates trivittatus*) which carries its tadpoles on its back. These tadpoles are very similar to those which we see in ponds in England; they hold on to their parents with their prehensile lips, and press their flat, moist abdomens close against their backs. These frogs spawn in water, the parent frogs remaining in the neighbourhood till the eggs are hatched.

The little tadpoles crawl on to their backs for the purpose, apparently, of being transferred from pond to pond. No doubt the action is entirely automatic, and it would be interesting to know what conditions prompted this action, and whether the parent frog when loaded up with its burden of tadpoles invariably made its way to another locality. In a tropical region, where pools are liable to dry up quickly, such an adaptation would certainly be useful. It argues however, an extraordinary degree of correlation between the climatic conditions, the behaviour of the parent frogs and the responsive behaviour of the tadpoles.

Another slight variant of this behaviour-pattern is provided by a mountain-dwelling frog from the Seychelles (*Sooglossus schellensis*). At an altitude of five thousand feet there is little still water to be found. The female lays her eggs amongst leaves. As soon as these are hatched, the tadpoles wriggle themselves on to the back of the male frog, and there retain their position partly by suction and partly by the help of a gummy secretion produced by the father. These tadpoles appear to live during their larval development on the parent's back, and are not there merely for the purpose of transformation.

Such frogs as those already described may be considered as the nurses of their offspring, in that they either provide them with nurseries or nests or, carrying them about upon their persons, contribute to their safety or convenience. There is, however, a further degree of solicitude that frogs exhibit towards their young. The Midwife Toad (*Alytes obstetricans*) was discovered in France in the very act which has given to it its name.

And it is a remarkable fact that a creature of such primitive development as a frog should show such a seemingly high degree of solicitude for its young, as does this animal. In this case, as in those already described, it is wiser to assume that the behaviour is almost entirely automatic, though that does not make it any the less wonderful. When we regard such life-histories, we are forced to ask whether such behaviour is the result of fortuitous variations or mutations in their response to environment, or whether some external or internal directive spirit is in these various and peculiar ways making itself manifest.

The male of the midwife toad seizes the female round the waist, after the usual manner of toads and frogs. With appropriate movements of his toes, he stimulates her to stretch out her legs, then places his own hind legs between them and bends up his knees at an angle, thus forming a kind of receptacle into which the eggs are laid. These eggs are yellow and are threaded together by sticky, elastic threads. Two to four layers of about ten eggs are laid. At the moment that the eggs are laid, the male shifts his hold on the female's waist to an embrace nearer to her head, and a little later stretches out his body in the act of fecundating the eggs. Again after a few minutes' interval, he attaches the strings of eggs to his own legs, passing his feet through the egg-cocoon, and then holding the gelatinous strings against his abdomen, so that the egg-mass bulges out round the posterior end of his body, he retires to a safe retreat, where he hides during the day time. At night he comes out to feed, and on these nightly walks the eggs are dampened by the dew. After three weeks he takes to the water, still carrying the eggs with him. By this time the tadpoles have hatched; they bite their way through the envelope of jelly which has held them together. Not till the last of the tadpoles are free of the egg-strings does the father frog disentangle himself of what remains. The tadpoles continue their life in the water in a way similar to other toads.

This curious behaviour is rivalled and perhaps surpassed by a Brazilian tree frog (*Hyla goeldii*). In this case the female takes charge of the eggs. Folds of the skin of her back form a dish-like receptacle, in which the eggs are placed. Presumably it is the male that helps her get them into this position. The eggs are comparatively few, twenty to thirty, and are well provided with yolk. They remain for the whole of their development on the back of the female, and from them emerge not tadpoles but little frogs, which still, however, have long tails. Instead of a large number of spawn being produced and being carelessly scattered, as with the common English frog, this animal lays but a few eggs, richly provided with food-material for the development of the young, and takes care of them by carrying them about on her back. Advantages over the more primitive, extravagant method are gained by the mother frog being able to seek out conditions suitable for herself and her charge.

A further development of the safe hatching-ground offered by the parental back is provided by a toad from tropical Brazil (*Pipa americans*). This toad, unlike the tree frog, lives most of its time in the water, yet it has adopted the same method of protection for its young; the skin of the back, in this case, instead of forming a mere flat dish to support the eggs, grows round them and over them, completely enclosing each egg in a separate cell. In these cells, each covered by a kind of lid, the young develop and emerge as tiny toads. This animal has a specially developed bladder-like pouch which projects, while the eggs are being laid, from the cloaca, and directs them backwards on to the female's back.

Other tree frogs of the genus Nototrema, also from South America, present variations of this same method of carrying the eggs on the back. In this genus a single pouch is formed by folds of the skin of the back growing together and leaving but a small exit through which the young, in this case tadpoles, can escape. And yet another variation of this highly specialised method of carrying the young in a pouch is provided by a small frog from Chili (*Rhinodermata darwini*). The young are carried in an enlarged vocal sac, which when fully developed covers the whole ventral surface of the body. It is the males, in this case, which carry the young, but how the young get into this sac has not yet been discovered. Yet other variations are offered by the female frogs (*Hylambates breviceps*), which carry their young in their mouths during their period of development.

The comparative study of the frogs and toads in their methods of reproduction offers a great number of variations. A more detailed and tabulated account can be found in J. T. Cunningham's work on Amphibia, but sufficient has been said, in the above short descriptions and life-histories, to show what different modes and expressions can be adopted by the purposive impulse of life to attain the same ends—and these within one group of closely allied animals.

Infant Voyagers

For a long while it was unknown to science where the eel spawned. Professor J. Schmidt, a Danish naturalist, in the course of several cruises, and with much patient and careful investigation, has found that the spawning place is near the Bermudas and north of the Sargasso Sea. Actually where the eggs are laid still remains unknown, but it is presumed in deep waters. The young fish, newly hatched from the eggs, are found in millions in this region, and in the regions westward, whither they are drifted by the movements of the currents. They measure at first but a few millimetres in length and a fraction of a millimetre in breadth, and possess a minute, globular head. These tiny fry are called *leptocephalus*, and were thought, for some time, to constitute a species of their own, and were not recognised as being the young larval form of the eel. Their growth is slow, and those members of this vast host whose future destiny calls to them from European rivers, drift with the Gulf Stream. Three months after they are hatched, they are twenty-five millimetres long, still almost microscopic, and three months later are between thirty and forty millimetres. They grow regularly without changing their leaf-like form.

For three summers these little creatures live in the sea, drifting their way, two thousand miles and more across the ocean, their vast numbers being preyed upon by all manner of creatures, as they make their long landward journey. At the end of three summers, when they at last reach the shores of England and France they are only sixty to ninety millimetres long, extraordinarily small for their age. During this first period in their lives they have remained exceedingly passive, feeding on substances dissolved in the sea water, and by their tiny movements merely succeeding in keeping themselves suspended.

Though they have been born of their mother eels as eggs, as leptocephali they are in the ocean waters invisible and transparent and inert; in the ocean they seem as passive as other creatures are within the substance of their mothers, and are carried by this, their second mother, the ocean, whither she will. The slow, sure currents carry them to the land.

At the end of three years, and while yet suspended in sea water, the leptocephali undergo a change of form; they become smaller, less leaf-shaped and more pipe-shaped, more like adult eels. They are now elvers, and no longer passive organisms carried along by the currents, but active little fishes. They are still transparent, and will so remain until they enter the rivers.

The question presents itself: What conditions produce this metamorphosis from leptocephalus to elver? Possibly the different type of water which they now encounter in the neighbourhood of the land. It is almost certainly more oxygenated and less saline than water further out to sea. Whatever conditions they may be that produce the change, the young elvers are undoubtedly attracted towards the fresh river waters. They enter the estuaries, and a short while later, lose their transparency and become both pigmented and opaque.

The numbers of elvers which approach the shores of Europe every year are enormously large. There are thousands of millions. Not even a dense swarm of locusts will outnumber this vast migration which comes up from the sea towards the land. Huge quantities are caught in fine-meshed nets and sent in train-loads to cities to be eaten. Tons of them are pickled and preserved to tickle the taste of the gourmet. They do not only push their way up the rivers and watercourses, but sometimes fling themselves upon the land, crawling over the wet stones of the beaches, and through wet grass in search of waterways which will lead them inland. On Romney Marsh I have seen thousands of these little creatures, which had climbed over the sea-wall near Dymchurch, and which were wriggling their way through the grasses. The dykes, both above and below the dams were full of them.

And so they work their way upstream, driven by a tremendous and all-compelling urge towards a quite unknown and altogether different form of existence. Though they are so small and so numerous, they are old in years and experience. Each one of them has travelled since the day of its birth, more than two thousand miles, and yet not one of them knows where it is going. As a corporate whole, as though driven by one will, they wriggle their way inland, sometimes in the rivers' mouths piling themselves up into stiff, jelly-fleshed waves of advancing life, myriads of individuals united in a oneness of purpose and desire.

Of those which escape the nets of the fishermen, and survive from the attacks of all the animals and birds which follow this host of young travellers to the shore, a fairly large number make their way up the rivers. These grow larger and stronger as they go, they seek the dark underbanks and travel mostly by night, avoiding the light. Two years after metamorphosis and five years after it was hatched, the young eel is about eight inches long, and its first scales are beginning to form in its skin. In another two or three more years, the males will become pubescent; the females which develop more slowly, will take another year or so. These latter are then thirty to forty inches long, being about twice the size of the males.

There is an interesting point about the distribution of male and female eels in their freshwater resting-places. In certain ponds or streams the larger females seem always to predominate in numbers, and in other localities the males will always be the more numerous. The distribution of the sexes, seems, in fact, to be determined by the localities. What is the cause of this distribution, and what is its result? The same migrations are urged upwards towards all these different localities, how is it that some localities are populated by males and some by females? Is it that the eels sort themselves out, the females going to one place and the males to another, or is it that the influence of the environment is able to determine the sex? If this latter supposition has anything in it, then we must assume that the elvers, as they ascend the streams, bear the potential of both sexes within them, and that male- or femaleness develops according to the influence of the environment. There are some naturalists who believe this to be the case, others hold, however, that the sex is already determined in the egg, and that the young eels sort themselves out, as our own children are sorted out when sent to boys' or girls' schools. The question remains open to further investigation.

During their stay in the rivers and ponds, eels are known to hibernate during the winter. They dislike cold, and they dislike light. They seek for warm, dark places, and there curl up and remain quiescent until the return of spring. When warm weather returns they become active once more. They have great vitality and as everybody knows they are extremely difficult to kill. Even when their bodies are cut up into small pieces, each part will remain wriggling. This vitality also enables them to resist and to survive in an uncongenial environment. When other fish are poisoned by polluted water, eels can live, and when ponds dry up, and other fish perish as the water disappears, the eels can burrow deep into what mud remains and provided there is but a modicum of dampness, they will survive.

After the eels have achieved the necessary growth, and the period of pubescence has arrived, they will, each and all, as soon as that critical period is come to them, be visited by that compulsive feeling which tells them that they must make their way out of their ponds, back to the rivers, and down the rivers, down towards the sea. It is during the autumn that this feeling comes to those who are fitted to take on their long wedding journey. These are the strongest and the oldest; the others not so strong or not so old are unaffected by this impulse.

When they reach the sea, they do not delay in the coastal waters, but make straight for the depths. In vast numbers they go, seeking the darkness and avoiding the light. As soon as they are fairly at sea, they disappear completely. They seem to lose themselves, leaving no trace behind. Occasionally an odd individual is caught in shallow water, but the vast majority disappears. We can trace their course no farther. We only know that when sexually maturing, they have gone down to the sea, and we know that the small leptocephali, their larval form, come from far across the sea, turn into elvers, which make their way up into the rivers, and grow into eels. Since the leptocephali are found at their smallest and youngest in the neighbourhood of the Sargasso Sea, we must conclude that the eggs are laid in that region of the ocean, and that the eels travel all that way back, swimming against the current of the Gulf Stream, being led in that direction by the attraction of the warmer waters, till they come to the predestined spawning ground. Why they have been led so far, and why to this particular place, we cannot tell, nor can we even guess. All we can say is: this is the pattern of their fate, the pattern they must follow.

What happens to the parent eels after they have mated and spawned we do not know. They are never seen again, they do not come back, either to the rivers or the shallow waters. The conger eels which are so frequently caught in the sea are not the same species of eel as are those which are found in our rivers. These true-river-frequenting eels, perhaps, like the salmon, die in large numbers when they mate, or perhaps live for many years in the deep sea. Only the growing period of this species is spent in fresh waters. The birth and the death, and perhaps the full maturity and ripe old age are accomplished in the sea. These creatures present the reverse habit to that of the salmon. They are deep sea-water fish which breed and spend their early youth in the sea; they wander across vast territories of the ocean to reach the land. They then spend their growing period in the rivers and ponds. The salmon can be considered a freshwater fish, that breeds in the mountain streams and spends the first period of its youth in fresh water. It then goes down to the sea, and in the sea remains during the period of its growth, and when pubescent, it returns to the rivers. Each species under its own peculiar compulsion accomplishes a destiny which must leave the beholder wondering and astonished at these strange interrelations between living creatures and their environment.

It should be mentioned before leaving this subject of the eel and his voyagings, that some few individuals fail to make the return journey to the sea. These—if confined in tanks or ponds from which it is too difficult to get out, and so be able to travel in response to the impulse of their pubescence—these must of necessity remain behind. They do not languish or die, but if the critical period for migration is missed and they remain where they are, their sexual organs become sterile. They grow large and sleek, become great gormandizers and live to a ripe old age. Such are the giant freshwater eels which are sometimes caught, and about which paragraphs are written to the newspapers by the proud fishermen who have hooked them.

Love and Hunger

The salmon, in their migrations from the deep sea into the rivers, come in groups and parties according to age and size. In autumn and winter come the largest, oldest fish. These are often a yard or more in length and weigh from thirty-five to forty pounds. As their scales indicate, they are five to six years old. In the early spring, groups of smaller fish follow, taking the same course up the rivers towards the source; these are mostly four-year-olds, and their weight varies between eleven and twenty-two pounds, and their length from twenty to thirty inches. In summer only a few fish come in small groups, these weigh six to seven pounds, and are almost all males. All these fish, whatever their size or weight, are bound for the same destination, and are moved by the same impulse to leave the deep sea where they have been feeding, and to work their way up through the fresh, strange waters of the rivers, up to the highest source, where the springs run cold and clear from the earth or from the dissolving snows of the mountains.

This journey is a journey towards a marriage rendezvous, and it is a remarkable fact that the salmon while engaged upon it eat very little food. It is true that they will snap at flies, but it seems probable that they get very little nourishment from such light trifles, for their stomachs when examined are found to be empty. The impulse which drives them upwards towards the heights of the mountains, is one which is so strong as to make them face, what would seem to an unprejudiced observer to be, insuperable difficulties. It is well known how salmon will jump again and again at falls and cascades, and where they are at first unable to make their way, they will wait till flood-water makes possible their ascent. Once the journey from the sea to the mountains is started, they have to fight their way upwards against the very water in which they live; they cannot slacken their efforts, for if they do, they will be carried back from whence they came.

In this ascent of the rivers, there is a definite course which is followed year after year by each successive migration. At the dividing of waters, where tributaries join the main streams, the fish choose one course and leave the other. This choice which at first sight would seem to be mysteriously their own, is determined by their reaction to the water in which they swim; they follow that which is most rich in oxygen. Their need, on this long wedding journey, is for a rapid and intense metabolism. Their sexual glands, which were small and undeveloped when they left the sea, have need to grow so large as to constitute a quarter to a fifth of the total weight of the females, and a tenth of the weight of the males. This change demands a rapid life process, a generous oxygenation of the tissues. The salmon, seeking the most foaming eddies, the fiercest cascades, gets ever nearer to the river's source, where the proportion of oxygen in the water increases continually, thus stimulating the fish to greater activity and vitality.

So far as the actual mechanism of this long journey is concerned, we can say that it is determined by reaction of the fish to the kind of water which surrounds it; but what is it which produces this sudden turning aside, or *tropism* as it is called, from the life in the deep sea, where the fish feeds greedily, to this other quite different sort of life in the river, where different conditions control and stimulate a different kind of metabolism? This question is not easy to answer in its deeper implications. We can say, superficially, that its sexual needs determine this change, but even if we accept so facile a statement, the fact is yet sufficient to stir our wonder that a deep-sea fish should be driven out of the saline and light-less waters where it is accustomed to find its food, into the exposed and fasting conditions of a freshwater river. Why, indeed, should it behave in this way? But first to return to the subsequent events in the life history.

The salmon, whether they are heavy four-year-olds or the light six-pounders of the summer migration, reach their destination by the late autumn of the following year. Here, amongst the shallow waters of the snowy mountain tarns, they prepare for the marriage ceremony.

They can go no higher, since the water is scarcely sufficient to cover them. For weeks and months they have been battling their way upstream, and now they do not rest, but dart about in a state of increasing agitation. They have not all arrived at the same time. The big, heavy salmon which started in the autumn have reached the spawning places early in the following spring; these wait till the winter, and spend as much as twelve or fourteen months in fresh water. Those which started later spend less time in the rivers; all are at the rendezvous for the breeding season which begins usually in December and January. In these shallow, highly aerated waters, which are constantly whipped into eddies and cascades, the life processes of the salmon are yet more accelerated. The colours are changed by the products of excretion beneath the skin, and the salmon appear indeed to be suffering from the intensity of their crisis; they are emaciated, with distended abdomens, for the reproductive organs have grown large at the expense of the rest of the body.

Often the males begin to prepare the spawning places, making longitudinal hollows in the bed of the stream. The females finish the work which the males begin; they press and rub against the stones, squeezing out an enormous quantity of eggs. At this period the female is accompanied by one or more males, which, following after her, press down with similar contractions, shedding their milt on the ejected spawn. The females go from spawning place to spawning place, leaving intervals of time between the laying of the eggs, for the eggs do not all ripen at the same time. The males follow them eagerly, and during this spawning period nothing seems to matter to them but the satisfaction of their desires; they are lost to all sense of fear, being completely under the compulsion of that urge which has brought them so far from the dark depths of the sea.

When the spawning is over, the salmon are near the end of their strength; they are emptied of those sexual products which all their best powers have gone to produce. Long, emaciated and muddy-looking, they are but shades of what they were; many though still living are on the point of death. All their excited vitality has burnt itself away, they let themselves go with the water, having hardly the strength to swim. Large numbers do not survive this period of profound depression. Those which survive snap ravenously at anything eatable, for they are starving; and slowly they are carried down by the current to the sea from whence they came. In the deeps of the sea they recuperate and become strong again, and when they have recovered their beauty and their strength, they will again, at the appropriate season, rise up out of their deeps to the shallow water and seek the river mouths, and the oxygenated water, which in the end stimulates them to that flurry of sexual activity which is the death of so many.

The eggs, which remain in thousands on the beds of the mountain streams, develop slowly into the small fry, which at length, in mid-winter, emerge from them. These, as yet but partially formed, drag a vesicle of yolk behind them. This vesicle only gradually becomes smaller, and is withdrawn within them; the fins harden and become pigmented; the fishlet begins to swim and gathers strength to face the current. By the spring it is an agile little creature, hardly larger than when hatched, but better formed, and recognisable as a young salmon. For two summers the young fish remain in the mountain streams where they were born. They are now from six to seven inches long, active, lively little fish, with bronzed backs speckled with black, their pearly sides adorned by light or dark blue patches. They are now called smolts, and at this stage begin their journey downstream towards the sea. They travel slowly and in stages, letting the water guide them in an idle, easy descent. At the river's mouth they meet the salt water for the first time, and here they wait for a while to get used to this change of condition before committing themselves to the sea. Then as though inspired with confidence, they strike boldly out into that new world of waters, swim into deeper depths, over the Continental Shelf, down into the dark, cold regions of the ocean, where no light penetrates.

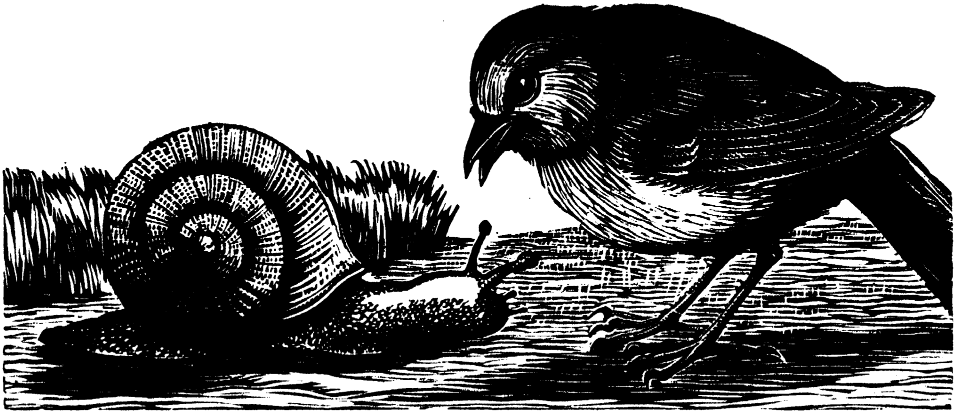
Since salmon are very seldom caught after they have left the rivers, it is a matter of inference what happens to them during their long stay in the sea. But as Louis Roule in his book on *Fishes, their Journeys and Migrations*, points out, our inferences are founded on facts which can bring us near to certainty. No salmon are found in the rivers which drain into the Mediterranean, therefore we may assume that the full-grown fish come from the Atlantic Ocean, and that the young fish go down into the Atlantic Ocean. Only very occasionally is a young salmon caught on the Continental Shelf, namely in the shallower waters near the land. It is probable that they go down to the middle depths, to three to five thousand feet deep. These middle depths, although devoid of vegetable life, since no light penetrates there, are very rich in animal life. Here there are hosts and swarms of crustaceans, and it is believed that the salmon feed particularly on prawns and shrimps. The carapaces of these shrimps are of a reddish pink, and it is this pigmentation of the shrimps which gives to the flesh of the salmon its characteristic colour. That delicious pink flesh that we eat so light-heartedly and take so much for granted, has been built up by the salmon in the dark depths of the sea where no human eye has ever penetrated.

For three or four years the growing fish are altogether given over to the business of feeding and the process of growing. They grow rapidly, at a rate which is far faster (double, even triple or quadruple) than that of other fish. They are great eaters, consuming and assimilating continuously. How in the darkness do they find their food? In these middle depths of ocean, life is so profuse that food surrounds them whichever way they turn. Swarms of red shrimps are rising up or settling down all the time; the salmon have but to snap their jaws to receive such easy victims, their gustatory and auditory sensations being sufficient guide.

So in the darkness they feed and grow, until they are moved by another kind of impulse. Perhaps they are wearied of that perpetual feeding; their hunger is satisfied, and another life moves within them, a turning aside from one expression to another. Their love for the rich, food-filled darkness is now replaced by a completely different desire.

Such a change as this is, of course, not peculiar to the salmon alone, though in the salmon it is particularly well marked. All migratory creatures have like experiences. In response to an impulse which comes from we know not where, perhaps from the unanalysed centre of their inner being, perhaps from the unlimited immensity of the surrounding cosmos, perhaps from both, they change their manner of life, and start on journeys whose destinations are quite unknown. For the salmon the destination must be unknown. The fish can but be aware only of the water which surrounds its body. The transition from saline to fresh must be a mystery to it; it has no knowledge of the river banks on either side; it follows the lure of the oxygenated water; that is all it knows, its need and its satisfaction. It moves under compulsion, and the end of its long journey is the spending of its vitality in the excited and extravagant spasms of reproductive ecstasy, an ecstasy most frequently followed by such exhaustion as to cause death. And one is tempted to question whether death is not the natural sequence of such devotion, such obedience.

Changes of heart, religious conversions, are for men as unexplained, as irrational as are these seasonal tropisms in migratory animals. They also mark the beginnings of journeys whose destinations are unknown.



The Millionth Chance

Creatures which live for a large portion of their existence inside the bodies of other animals find many difficulties in providing for the safe housing of their offspring. Although the parasite is comparatively secure when surrounded by the warm and living body of its host, there are numerous hazards to be met before the next generation can find itself in an equally advantageous position. How is it possible for an animal living within the body of another animal to get its young into the body of another similar host? To get from one enclosed retreat into another must be at the best a chancy business when the individual concerned is only adapted to a highly specialised and protected form of life, and would inevitably perish if it ventured in person amidst the inclemencies of the surrounding universe. The answer to this problem, which in all probability emerged at the same time as the conditions which evoked it, is found in most creatures by the production of an enormous number of eggs. These eggs are cast out into the world, the greater portion of them destined to destruction, and the few that survive, surviving by the merest chance, or often by a combination of chances. These few, these ones out of millions, are sufficient to carry on the species.

The parasitic animal, when it is completely enclosed within the body of the host, has very little to do in regard to the normal processes of living. It has no need for sight, since it lives entirely in the dark; no need for hearing, little or no need for taste, since it is often surrounded by the food which it absorbs through every portion of its skin. It has little need for touch or for movement, and many internal parasites are altogether inert. Its digestive organs can afford to be of the most primitive nature; its sense organs atrophied. The sexual organs are thus able to occupy the whole attention (if I may use such a term) of the individual. They grow large, often complicated, and self-fertilising, so that one isolated individual does not need the co-operation of another for the production of fertile eggs. In some cases the sexual organs occupy practically the whole of the body space of the parasite. They produce a vast quantity of eggs, of which only a very few are able to survive the dangers and difficulties which must inevitably intervene between their leaving one host and arriving safely within another. Strange and circuitous paths must be followed, and the pattern of each specific destiny would seem to have been determined by the most unpredictable chances.

In such animals as these, although they vary in many ways and derive from different orders, we find the following main characteristics. The sense organs, ambulatory organs and digestive organs are all atrophied or poorly developed, and the sexual organs are enormously developed; the life histories are complicated and often carry the parasite through the bodies of several hosts before bringing them back into the body of that host from which the eggs in the first place were liberated.

An extreme example of the growth of the sexual organs of an internal parasite is offered by *Spherularia*, a very small nematode worm. This worm lives in a free condition amongst the moss and earth composing the nests of humble-bees. After the worms are mated and fertilised, they attach themselves to the humble-bees and work their way into the body-cavities of the insects. Inside the bees they wander about in the body-cavity, where they obtain nourishment by absorbing fluid food through their skins. As soon as the worm is safely inside the bee, and it has taken up a parasitic form of life, the uterus of the worm begins to grow, it becomes so large that it pushes itself outside the body of the worm, and continues to grow enormously. It becomes vastly larger than the worm, which soon appears as a small appendage to the swollen uterus. Eventually the body of the worm withers away and disappears, the uterus alone remaining in the body cavity of the bee. The uterus bursts, liberating a large number of eggs; these hatch into larvae, which penetrate the gut-wall of the bee and so pass out on to the soil and there become free-living, until such time as they can happen upon a bee's nest and pass again into another generation of bees.

Such a life history is comparatively simple, and is far surpassed in complexity by that of the liver fluke. The adult liver flukes which are short, flat, unsegmented worms are provided with suckers by which they hold their position in the bile ducts of sheep. They are the cause of liver disease, and besides being found in sheep occasionally occur in man. The adult flukes are hermaphrodite and produce a very large number of eggs, which pass out into the gut of the host, and from thence, in the droppings of the host, to the outer world. The eggs, if they happen to fall in a damp place, hatch into a small ciliated larva or embryo; this creature wriggles about on the wet grass, and if it is lucky, or if aided by a fall of rain, may find its way to a pond. It can swim in water; and, again if it is lucky, it may happen to encounter a water-snail. In contact with a water-snail, it has an impulse to bore into the soft flesh. It works its way through the snail till it reaches the blood stream, and ultimately the liver. Here it forms a cyst, which cyst has the power of giving rise, through a multiple budding-process, to a number of larval forms called redia. Each redia has the power of producing more redia, and so on for many generations within the snail. The redia at length give birth to a different form of larvae, called cercariae. The cercariae are provided with long tails, they leave the snail and swim about for a short time in the water of the pond. They finally crawl up grass-blades, and when free of the water, they encyst. They then wait inactive, and the majority of them perish, since they are unable to proceed any further unless they happen to be eaten by a sheep. They must also have the good luck to be swallowed by the sheep without being crushed by the teeth. Inside the sheep, the cyst develops into a young fluke, and may, if it is again fortunate, be able to enter the bile duct, where it grows to be an adult fluke and capable of producing in its turn a large enough number of eggs to meet the many hazards of its fate.

This animal, as it has been seen, must encounter many favourable chances if one of its many eggs is to survive and grow to an adult. In the first place it must have the good fortune to be dropped in a moist situation. It must then be able to find its way to a pond. It must then be able to find a water snail; no easy thing for so minute a creature in a comparatively enormous pond. Inside the snail it reproduces itself a thousand-fold. The proceeds of this reproduction escape again into the water as free-swimming creatures. They must now reverse their earlier journey and find the shore. Throughout these various activities, they appear to be led by some guiding principle which is responsible for the ramifications of a destiny, so well synchronising with their needs. Having at last reached the grass blades, the cercariae encyst, and here again they are either the victims or the favourites of chance. Should they be eaten by a sheep (and how many chances are there that they should not be?) they survive to carry on their species—that enigmatical expression of life which preys upon two such dissimilar creatures as a sheep and a water snail.

Another allied worm which shows several resemblances to the liver fluke in life history is the lung fluke. This worm enters the body of a man, being swallowed in uncooked crab's flesh. The flukes develop in the lungs, causing illness. The eggs are coughed up, and spat out. If they happen to fall in water, they hatch into ciliated larvae. These swim about until they meet a snail, which they enter. In the snail they produce redia, which produce other redia, and finally cercariae. The cercariae work their way out of the snail, and should they meet a crab, penetrate into its flesh, where they encyst. They can develop no further unless the crab is caught and eaten by man in an uncooked condition. This animal has three separate and different kinds of hosts, and must make three hazardous passages from one to the other before the life-cycle can be completed.

Leucochloridium is another trematode worm, inhabiting the intestines of small birds such as hedge-sparrows, robins and warblers. Its eggs are laid in the intestine and pass out with the droppings. For their further development they must be eaten by a snail. The larval form develops, in the snail, into a cyst of a peculiar kind which sends growths up into the snail's tentacles. These growths are brightly coloured and possess a rhythmical pulsation. These bright-coloured objects with their noticeable movement are liable to attract the notice of small birds, which latter, being often of an inquisitive nature, are liable to peck at and eat them. These birds it should be noted are too small to eat the whole snail. As soon as the coloured cysts are within the guts of the birds, they develop into adult trematodes. It is probable that only young birds are infected in this way, the adult birds being able to digest and so kill the cysts. How interesting it is to speculate on the destiny of the snail, which is infected by the sporocyst of the trematode and whose highly coloured and unnaturally bright tentacles are snapped off by the unwary birds. Must we not inevitably see in this relationship a parallel to the more subtle and hidden associations which occur in human beings, and which are only recently being revealed by the researches of the psycho-analysts? Were there a modern Aesop, how pertinent a fable might he not write!

The tapeworm, which is so prized by those races of mankind which measure their manhood by the amount of food which they are able to ingest, is another example of an animal, degenerate in everything but its sexual development, and whose destiny, governed by hazardous chance, completes a cycle within the bodies of various hosts. The tapeworms are to be found in men, pigs, dogs and rats. In men who eat mightily they are by no means an unwelcome parasite, for their demands on the nutrient juices keep their hosts always hungry. Indeed I have known a doctor who boasted that he made a habit of giving to his more gluttonous patients the scoleces of tapeworms secreted in bread pills. The resulting infection would reduce the weight of the patient, and at the same time allow him to indulge in the pleasures of the table with greater impunity. I have heard it said that no Arab is considered healthy unless infected by one of these obliging parasites.

A tapeworm may be considered as a string of degenerate individuals, each consisting of a sac-like body with but the most rudimentary nervous system, and devoid of limbs or digestive tract. Nourishment is taken in from the surrounding medium through the skin. Each individual contains an elaborate hermaphrodite sexual apparatus, and each is budded off in turn from the head or scolex, which, with its hooks, is firmly fastened to the wall of the host's intestine. As the individual segments grow further and further from the budding scolex, they grow in size and maturity, until, when they are full grown and fully ripe, they break off and pass out with the faeces. They have the power of moving themselves for short distances by the contraction of their muscles, turning themselves over and over, like so many animated portmanteaus. Should they be fortunate, they are dropped in damp grass. Ultimately they burst and let loose a vast number of eggs.

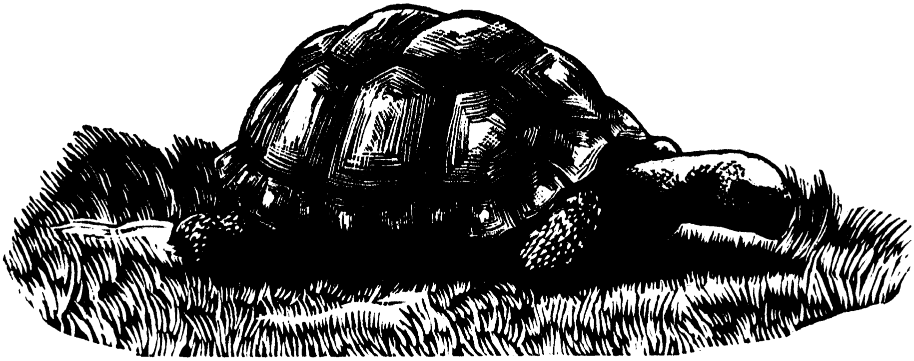
The ensuing life histories vary with the different species. In the Pork Measle Tapeworm the scolex develops in the intestine of a pig, the segments pass out on to the earth and there burst. The embryos which emerge from the eggs are, if they are lucky, swallowed by another pig. They then penetrate the gut and enter the blood stream. From thence they pass into the muscles, where they encyst. There they must remain until the host is either eaten by another pig or by man in an uncooked or semi-cooked condition. As soon as the cyst finds itself in the alimentary tract, a scolex is developed, and this will bud off segments forming a typical tapeworm.

Another comparable life cycle is provided by the broad tapeworm. This is adult in man. The eggs escape from the segments in the faeces. These can only develop if they are dropped near water. Swimming embryos emerge, and should rain and the slope of the ground favour them, they make their way to a pond. Here, if they are to develop further they must be swallowed by a cyclops, and again, if they are not to die with the cyclops, the cyclops must be in its turn swallowed by a fish. The fish must ultimately be caught and eaten in an uncooked condition by man for the tapeworm cycle to be completed. In this case the chances against the survival of any individual egg and the proceeds of that egg, seem fairly heavy. Only the enormous number of eggs produced can compensate for these adverse chances.

In contrast to creatures such as the tapeworms which inhabit various hosts, there are other worms, and these of a less degenerate nature, which live all their cycle in one animal, and explore, during their different stages of development various parts of the body of that animal. *Ascaris Lumbricoides* is a round, fairly active worm, which, in the adult form, inhabits the intestines of a pig. The eggs of the worm pass out in the droppings, they are picked up from the ground by another pig and swallowed. They hatch in the small intestine. One might suppose that this short cycle was now complete. The young are back in the intestine of another infected individual. All that would seem necessary is that they should develop and produce eggs in their turn. The cycle is not, however, so simple. The young worms burrow through the walls of the intestine, enter the blood system and travel to the liver, thence to the heart and thence to the lungs. Here they cause irritation and bleeding. They are coughed up into the windpipe and thence to the mouth. They are again swallowed, and when, for the second time, they enter the intestine, they develop into the adult form, and produce eggs.

Trichinella spiralis is another non-segmented round worm whose adult form inhabits the small intestines of men or rats. The females do not lay eggs, but give birth to larval forms, having first bored through into the lymphatic spaces adjacent to the intestinal wall. The larvae pass from thence into the blood system, and finally into the muscle fibres, where they encyst. They can develop no further unless the host that they are inhabiting is eaten by another animal. They are then liberated by the juices of digestion. They pass into the intestine, where they cause great irritation and disturbance. They are now adult, and the cycle is complete. Such a creature as this is not common in civilised countries in normal times, as the conditions favouring its propagation are not present. In times of war or plague when human bodies may lie about unburied, and may be eaten by rats or pigs, then the necessary conditions are supplied. The cycle may also be completed in the rat and the pig, the adult form of the worm occurring first in the rat, and the rat being subsequently eaten by the pig.

The above life histories are but a few of the many and intricate patterns formed by internal parasitic animals, animals which are all characterised by a high sexual potency, competent to produce a sufficient number of eggs to compensate for the risks and dangers which must be met in the passage from one host to another. What is most remarkable about them is the seemingly directive impulse which brings the straying larval forms back after many adventures to the place from which they started.



Tortoises and Turtles

The ancestors of the tortoises and the turtles are unknown. If we are to suppose with the evolutionists that they are descended from ancestral forms, then those ancestral forms have failed to make their appearance amongst fossil remains.

Tortoises are distinguished by the hard and rigid shell which encompasses them. The upper portion of this is called the carapace, this is formed of bony plates which originate in the skin; the upper plates of this carapace lie directly upon the spines of the backbone and on the ribs, to which in the course of their development they become welded. There is consequently no space in which the limb girdles, should they retain their normal position, would be able to function. The limb girdles lie in all other reptiles, and in all other vertebrates, between the ribs and the outer skin. In the tortoises and in most of the turtles, the dermal plates and the ribs and the backbone are fused together and so the limb girdles are conveniently placed inside the ribs.

If we assume that the tortoises have been evolved from some ancestral form, from which other, more normal reptiles have also derived, then that ancestral form must have either had its limb girdles outside its ribs, or inside. In either case a great and startling change must have taken place when the limb girdles were transferred either from the inside to the outside or from the outside to the inside. Such a change is impossible by any series of slow continuous variations. If such a change occurred as the result of a mutation, then such a mutation, which involves the removing of a girdle of important bones from the outside of the ribs to the inside of the ribs, and the consequent necessary changes in the muscles and all the interior organs of the body, such a mutation may well be called a separate act of creation.

In the tortoises we find a large group of animals reptilian in their characteristics, and yet separated from other reptiles by so fundamental a difference as this placing of the limb girdles. It must either be assumed that they were created very much in their present form, and have since like all other creatures suffered various changes through devolution from their archetype, or that they are evolved from some extinct and altogether unknown reptilian forms which were essentially different, in such an important respect as the placing of the limb girdles, from the ancestors of all the other reptiles. In this latter assumption we are still faced, if we trace our two lines of descent far enough back, with parallel development, which parallels cannot meet unless we postulate its extraordinary *mutation* which transfers the limb girdles from one side of the ribs to the other. This, as I have already said, might as well be called an act of creation as a mutation, so great are the corresponding changes implied.

The tortoises in this way present the evolutionists with a knotty problem, and it would almost seem that in contemplating the tortoises, we are forced to believe that at a certain period in the earth's history, they were precipitated. They are exceptional creatures, enclosed in a plated box, and, as a result of this enclosure, the majority of the muscles of the trunk are completely lost in that part which touches the shell. Traces, however, of these muscles exist in young specimens. Tortoises are creatures completely adapted to finding protection within their shell, they live enclosed within it, with only very limited capacity for movement. They cannot even bend their bodies, only can they thrust out and withdraw their heads, and walk slowly on their toes.

As the carapace is so strangely modified to unite the skin and the ribs, so the under-plate or plastron is formed by a union of the dermal plates with the collar bones and with presumably the abdominal ribs. The marginal plates of the carapace which join with the plastron are formed only from the skin and make no corresponding fusion with any part of the internal skeleton. In some cases, as in ordinary land tortoises, the carapace is joined to the plastron by a bony bridge, so that the whole structure forms a firmly built box into which the head, limbs and tail can all be withdrawn; the horny beak and the horny shields on the legs effectively guarding the apertures.

The marine turtles though built on the same general plan are not so completely protected as the land tortoises; the upper and lower halves of the shell are disconnected, and the head and neck cannot be withdrawn under the margins of the carapace. The four limbs are modified into flippers, the digits of which are lengthened, but without increase in number or marked alteration of form. The body is flattened, as compared with the tortoises and heart-shaped. These modifications allow of an easier passage through water. It is probable that the marine turtles are derived from the land tortoises, and in most cases the dermal plates are welded to the ribs and backbone as in the tortoises. The leathery turtle or luth is an exception. The upper and lower portions of the shell of the luth form one unbroken case all round the body. This case is composed of many hundreds of little bony plates, closely fitting into each other like a mosaic. These plates are deeply embedded in the skin, covered by it both externally and internally. They are nowhere in contact with the skeleton, except at the nape of the neck.

Different opinions are held as to the position of the luth in relation to the other marine turtles. Some biologists regard it as a degenerate modification of the normal type, others regard the luth as an independent type of different origin. This is indeed a most puzzling creature. Its form and structure express the same idea of protection and adaptation; but different means and different shape and size of the protective plates, and a quite different arrangement of them, have effected the same ends. If we are to make any inference from the contemplation of such an expression of life, then we must believe that certain ideas are materialising in animal forms, and that the means by which these ideas are manifested are not always the same. Nature is expressing invisible values through visible forms.

Turtles and to a lesser degree tortoises are possessed of an extraordinary vitality. They are extremely difficult to kill. On the first occasion that I had camped on a tropical island (we had arrived in a sailing boat at night, and had set up our beds on the beach) one of our party found, in the early hours of the following morning, a female turtle that had come to lay her eggs in the sand. He turned the turtle on its back, and came to tell us of his find. Since we thought we might be hard up for food on that island, we light-heartedly decided to kill it, and set out, thinking the task might be accomplished by breakfast time. There were three of us and we had knives and a good rope. By midday we had managed to cut its throat, and remove most of its internal organs. The heart continued to beat in a small pool of sea water in which we placed it, pumping the water in and out as though it were its accustomed blood; this it continued to do for several hours. The rest of the turtle, minus its inside, continued to beat its flippers to and fro till they were cut off. Blood-stained and exhausted we separated the upper and lower shell (no light task), and cut some of the meat up into steaks. These steaks of meat, which we placed on ledges of rock to keep them out of the sand, wriggled and crawled off the rocks by means of their contracting and expanding movements. Never, never we decided would we ever attempt to kill a turtle again!

Besides having a tenacious vitality in all their parts, tortoises and turtles are also extraordinarily long lived. 'In the year 1766 five tortoises belonging to the species *Testudo sumerrei* were taken from their island in the Seychelles and were carried to Mauritius, where two were living a few years ago. The most celebrated of the pair is one at the Artillery Barracks, Port Louis, of which the shell measures forty inches in length in a straight line. Since the dimensions of the shell are reported to have been practically as large so long ago as the year 1810, it is certain that this tortoise must have been very old at the time of its arrival in Port Louis; and something over a century would probably be a moderate estimate of its age at that date. Accordingly, it would seem that the reptile cannot be much less than 250 years, and may be much more.' Other cases of the extreme age of tortoises and turtles are not hard to collect.

Among the more unexpected qualities of tortoises is the power that some species have of making a kind of whistling or piping noise. The peculiarity of this noise is that it is produced by rubbing together two patches of horny tubercles on the hind legs. The note that this friction gives is clear and audible at a considerable distance. These tubercles are formed only on the male, and the notes are only produced during the breeding season. These same tortoises which can produce this sound are provided with a very strong-smelling secretion which can be exuded at will, and which has given to them their popular name of 'stink-pot terrapin'. This fetid secretion is no doubt a means of defence. Tamed specimens of this tortoise do not produce this bad smell when they have become accustomed to being handled.

In his account of the Galapagos Archipelago, Darwin tells of the giant tortoises which inhabit these islands. The Galapagos Islands are volcanic in origin and, measured in geological time, not of very long duration. They are between five and six hundred miles off South America, and they have a flora and fauna of their own, which includes many South American species. There is only one indigenous mammal, a small mouse; but in the absence of mammals there is a large population of tortoises. In the same way that New Zealand, in the absence of mammals, is populated by flightless birds, so are the Galapagos Islands populated by tortoises. They are large and black, and weigh as much as two hundred pounds and more. How they got to the islands no one knows. When first discovered, they were exceedingly numerous. They live chiefly upon cacti and lichens, and since the islands are very short of water, often have to walk a long way for a drink.

Darwin describes how that he found these large tortoises to be almost completely deaf. 'I was always amused when overtaking one of these great monsters,' he writes, 'to see how suddenly, the instant I passed, it would draw in its head and legs, and uttering a deep hiss fall to the ground with a heavy sound as if struck dead. I frequently got on their backs, and then giving a few raps on the hinder part of their shells, they would rise up and walk away; but I found it very difficult to keep my balance.' This was a young Darwin of twenty-four, not the venerable figure with whose picture and statue we are all so familiar.

Herman Melville, the author of *Moby Dick*, also describes these large black tortoises, and found in them the same quality that I have found in turtles, namely an obstinate desire to go in a straight line. I have known a turtle push for three days at the same place in the side of a stone pen in which it was enclosed. At the end of the third day it pushed aside the boulder and escaped. Melville describes a tortoise from the Galapagos Islands, which had been brought on board a ship, pushing for a whole night at the base of the mast. He goes on to describe how he has 'known them in their land journeyings ram themselves heroically against rocks, and long abide there, nudging, wriggling, wedging, in order to displace them, and so hold on their inflexible path. Their crowning curse is their drudging impulse to straightforwardness in a belittered world'.

Ancients of the Earth

The Australian bush in the region of Southern Cross and some thirty miles south of the Perth and Kalgoorlie railway line is semi-desert country. The granite plains are covered with sparse scrub of mulga bushes. The red dusty earth is bare of herbs for the greater part of the year, and only after the short, occasional rains do there follow sprouting and blossoming periods, soon to be withered and dried up by the sun's heat. Besides the mulga, malle and cassurina bushes, there are occasional clumps of white gum, and here and there solitary salmon gums; and over the red dust are littered the remains of such occasional trees which have lived there in the past, and have fallen, to rot where they lie. These tree trunks soon become hollowed out by ants and other insects. The inside of their stems appear to be softer than the part immediately under the bark, and so, in the process of decay, there is a period when these fallen tree trunks form easily excavated tubes in which small animals can find shelter and safety.

Rabbits are the chief inhabitants of these tree trunks, but bandicoots, boody-rats, snakes and other creatures also use them. So also do the echidnas or bush porcupines. These very primitive mammals are interesting for various reasons, and while I was in Australia I collected some half-dozen, which I kept alive, and had hoped to bring back to England.

The method of capture was as follows. I borrowed a dog with a 'good nose' from one of the miners who was working at the Bullfinch, a mine which was destined to become world-famous a few weeks later for its rich veins of gold ore. With this dog, and armed with an axe and a large sack I went hunting. The dog would smell at the logs, and if there were a rabbit or an echidna in the log, he would scratch at the place where the animal was. A piece of wood could be used to block up the open end of the log, and then, when it was split open, the animal could be captured or killed. There were more rabbits than echidnas; but by hard work I managed to collect six of the latter. These I kept alive and tethered out in the neighbourhood of my tent. At night-time they were noisy companions, grunting and sniffing and straining at their tethers and scratching at the earth, but I managed to keep them all safely so long as I was in the bush, and during this time I learnt something of their habits and their appearance.

During the daytime they would remain under the sacks which I left for them to shelter under from the sun. If the sacks were removed, they would press themselves close to the earth, and tuck their long noses under their bodies, as though hiding their eyes from the light. In the evenings, provided all was quiet, they would walk to the limit of their tethers, and would sometimes eat ants with their long extensile tongues.

These specimens which I kept in captivity for varying periods from a week to a month were always very shy, and not, like bandicoots, easily tamed. An observer must keep very quiet and at a distance to see them in action. Sometimes I would let them go free and follow them, and once had the good fortune to see one dig out an ant's nest and make a thorough good meal of the ants. When my echidnas imagined themselves to be free and unobserved they could go at a fair pace, holding their bodies well up from the ground and flattening their quills upon their backs. None of my specimens had young during the short time they were with me, for I was too late for the breeding season. It is in September that the mother echidna lays her egg. The egg is soft-shelled, and it is probably laid directly into the pouch. The young is hatched in the pouch, where it suckles like any other young mammalian. During the time it is in the pouch it appears very helpless and quite unprotected. Later, when it has grown its first few quills, it is deposited in a nest in some dry, safe place, where it remains till old enough to be weaned and able to look for ants for itself.

I was told by Australians who had been fortunate enough to capture these creatures when they were young, that they made quite tame pets, coming when they were called and following their owners about like dogs. My own echidnas remained wild and distrustful, and finally escaped in the hotel at Southern Cross. I was hoping to keep them with me till my return to England. For safety I had them in my bedroom, and since I was sorry to keep them constrained in sacks, I loosed them for the night, after having locked the door to make sure they should not escape. As soon as the light was out they began marching round the room, pressing themselves between the wall and any piece of furniture, shoving the furniture about, and threatening to upset a heavy wardrobe. However I did not think they could come to any harm and so went to sleep.

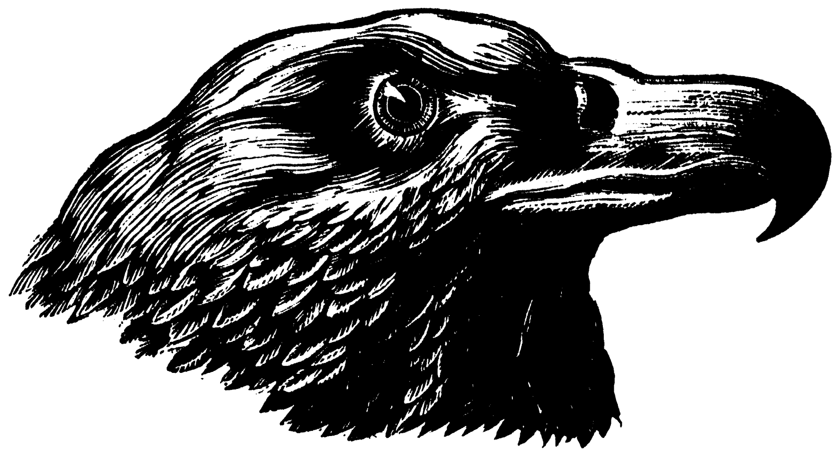
When in the morning I woke up, I found every piece of furniture out of place, and no echidnas. They had managed during the night to lift up a loose board in the floor, and had escaped under the hotel. There unfortunately I had to leave them, since the space between the flooring of the hotel and the earth was too small for me to crawl in after them. Both myself and the proprietor of the hotel were much annoyed at this unfortunate ending of my adventure with echidnas, but for different reasons. He thought they would disturb the other guests in the hotel by shuffling and digging under the other bedrooms, and I was sorry not to be able to keep them and observe their interesting breeding habits. One deduction at least I was able to make from this adventure: that these comparatively small animals were able to push about large pieces of furniture. This they did, no doubt, with the strong digging muscles of their backs and shoulders.

An allied and equally peculiar creature is the Ornithorhynchus, or Duck-billed Platypus. This animal is not found in Western Australia, but I have seen them in Tasmania, and they inhabit most of the rivers of Eastern Australia. The platypus burrows in the river banks and swims in the water, and likes a dry and warm nesting place. For swimming it is provided with webbed feet. These webs, which extend beyond the length of the claws, can be withdrawn and folded under the foot when the animal is running or is using its claws for burrowing purposes. As a digger it is very expert. It has some sense-perception which enables it to be aware of the proximity of other burrows. It will most skilfully avoid breaking into these, whether these burrows are self-made or by others of the same species or by creatures of different species, such as water rats or rabbits. When engaged in its burrowing operations it may chance to come near to these other tunnels, it will alter its course so as to avoid them. In making its own tunnel, it is most careful to conceal the way which leads to the underground nest. The burrow is long and winding, and will usually be provided with more than one false ending—a foot or so of soft worked earth which blocks the hole. The hole will, however, continue beyond this. Several of these false endings are found before the nest is reached. The defenceless young are in this way protected by what we call the instinct of the mother platypus for making false endings, which would turn back any predaceous creature that had penetrated far along her burrow.

The platypus, like the echidna, lays eggs. These are often produced in couples, and are attached to one another. They are laid in the nest and hatch into small, completely helpless creatures. The mother has no pouch, but holds the young to the teats by her flexible tail which bends round them and so holds them in position. The tail is a remarkable feature. It is broad and flat, and like the beaver's tail is of great use in swimming and diving. One of the most obviously remarkable things about the platypus is the duck-like beak, which is horny and broad and flat, and is used in much the same way as the duck uses its beak, for sifting out food from a watery medium. The food, which consists of insects, worms and freshwater crustaceans, is collected under water, and is held for a short while in the two pouches there are on each side of the mouth. When the animal rises to the surface it will grind up the creatures it has secured in its cheek pouches with the horny plates of its bill.

The fur on the Tasmanian specimens that I have seen is remarkably fine and thick, also rather greasy and well adapted to keeping the animal dry. The platypus is a great swimmer and diver, as swift in movement as an otter, which is saying a good deal, and can float on its back, in an amusing position, with tail and head raised well above the surface of the water. On the inner side of each hind leg there is a horny spur. This is hollow, and is connected with a gland which secretes a poisonous fluid. What this spur and poison are for is not known, but it is assumed that the spur is to be used for defence, though no case is known where the animal has used it for this purpose. The fluid has however been extracted from the gland and injected into a rat. The rat died shortly afterwards.

Both the echidna and the platypus are remarkable and interesting animals. They are considered to be the most primitive of all mammals, and are believed to form a link between reptiles and mammals. They have several reptilian characteristics, as for example the bony structures of their limb-girdles, and the fact that they lay soft-shelled eggs. They are mammals in that they suckle their young, and the mother echidna resembles the marsupials in that she carries her young in a pouch. It is considered probable that both these animals are survivors from earlier types which have been exterminated elsewhere. How closely they represent those hypothetical, extinct types we cannot tell. The process of specialisation and devolution may have gone far in them, and they may now be very different from the archetypes from which they are derived. But, such as they are, they must stimulate our wonder at their strange combination of qualities, which combine primitive reptilian characteristics with those of mammals.



The Eloquence of Eyes

The eyeless worm in its search for a satisfactory environment is an opportunist in so far as it lacks vision and the judgment which comes with vision. Its sensitive snout feels a way, testing the different qualities of earth, these grains which are hard, and these which are softer, and these others which give a promise of decomposing leaves. It lives by trial and error, and in its darkness is devoid of understanding. Animals which have eyes possess with their function of sight an enhanced consciousness, and the judgment which follows their vision will often indicate a more direct method of attaining their ends than the acceptance of the easiest path—not always the shortest.

Compare with the worm the hawk or the eagle, which, sweeping in easy flight over mountains and plains, sees a whole countryside spread beneath. The bird can discriminate which district is dangerous, which likely to yield food; small signs are not lost; and the messages which the light brings to its brain are tokens of experiences both past and to come. The large and brilliant eyes of the eagle are to our own human scrutiny so remarkable that they carry at once a conviction of their great efficiency.

Once it was my misfortune to shoot an eagle—a deliberate misfortune, for I had spent several days stalking the sea-eagles over the barren, brush-grown rocks of Bernier Island in Shark Bay. I had never succeeded in getting within range, for though the eagles in that remote place can have had little experience of men with guns, they were very shy. I had noticed, however, that often when I was bathing, an eagle would come near and hover above me, and once it had swooped alarmingly close. I took my gun to the beach and, having taken off my clothes, lay down with it at my side. The eagle, as it had done before, came and hovered in curious regard of my nakedness. I shot, but did not kill it. It came fluttering down into some bushes not far distant. I then had to capture and kill the eagle—no easy task.

Although I was excited and my senses consequently deadened, they were not so deadened but that I must perceive the beauty of the eagle's eyes as they glared at me full of terror and indignation. Here was a beauty absolute and convincing; these eyes were adequate receptacles of the light which they were fashioned to receive; and as I watched the life fade in those marvellous orbs, I was ashamed that I should have shot this bird for a mere dinner.

All highly developed and efficient eyes are beautiful. The mosquito's under a lens, are domes of many-coloured glass or crystal; their opalescent facets are set upon the larger portion of a sphere, and look out many ways. A dragonfly's eyes are even more remarkable, and their darker pigmentation gives to their massed, narrowed and deepened cups an iridescence ranging from pale green, through all the shades of blue, to black. How much the vision of such compound-eyed creatures differs from our own sight we cannot know; and though contrivances have been devised through which photographs have been taken through the compound eyes of insects, and though those photographs produce a picture, whether that picture is the same as is received by the consciousness of the insect, we cannot be sure. But what we can be sure of is that the compound eyes of insects are very efficient organs, and that their possessors see with them remarkably well. We have only to observe the dragonflies as they watch for and catch smaller insects to be sure of this. Their function is perfect, and the beauty of such eyes, though not so vivid and personal as that of an eagle's, is no less indicative of their light-receiving quality; and though so different, they are equally convincing as organs of an increasing and discriminating consciousness.

The simple eyes of the higher animals are subject to the most interesting forms of adaptation. Many of such adaptations to particular environment are shown by fishes. The eyes of fishes which live at great depths, and consequently in darkness, are usually large and well developed, that they may be competent to catch the faint lights from the phosphorescent creatures which live beyond the reach of sunlight. Some few of the creatures which live in the abysses of ocean are blind, but these are members of those species which habitually burrow beneath stones. Their eyes are vestigial and functionless, and the eyeballs are often collapsed. In other species, the eyes have completely disappeared, leaving no trace. There is a fish, living at a depth of 1260 fathoms, which has its eyes covered with skin. This suggests that the organs, unable any longer to function in so prevailing a darkness, were of no value to their possessor and had, with the passing of generations, become invaded by tissues which under more normal conditions would be controlled and restrained by the co-ordinating dynamism of its life.

Blind fish are more commonly found in dark caves than in the depths of the sea. In the caves of Kentucky and Pennsylvania there are several species of completely blind animals. In these waters is utter darkness, there being no phosphorescent organs carried by their inhabitants. Those fish are also blind which live the whole of their lives in holes and crannies, as for example a small goby which lives in burrows made by a shrimp. The shrimp, which often emerges from its retreat, is not blind; but the goby, which never leaves the burrow, is blind.

One of the most interesting examples of adaptation amongst fishes is a little freshwater fish inhabiting the rivers of Central and South America. The eyes of these fishes (*Anableps*) are divided horizontally into upper and lower portions. The eyes are large. Projecting across the front part of the cornea is a pigmented band; the pupil is also divided by a corresponding partition of the iris, and the curvature of the lower half of the lens is more convex than the upper half. This horizontal division of the eyes corresponds exactly with the level of the water in which the fish swims, so that the upper portion of the eye is in the air and sees the objects which are above the water level, while the lower portion looks downward and can see those things which are under the water. These fish have a habit of swimming in schools on the surface of the rivers. They eat such things as they can pick up on the surface, and are seldom seen to jump out of the water or to dive under it. When on rare occasions they do dive under, they have difficulty in keeping down, and soon come up again. It is interesting to notice that the eyes of these fish develop in their earlier stages in the normal manner, and that the peculiarity of the horizontal division is secondary. In the youngest embryos the eyes are simple, as in ordinary fishes; in later stages the iris develops lateral projections, and finally the cornea is divided by an horizontal band. The history of this development in thc individual would appear to indicate the development of the race. The ancestral form of the *Anableps* would have, we would suppose, normal eyes; but since these fishes had the habit of swimming on the surface with their eyes half in and half out of water, they became gradually adapted to this condition. Such a history demonstrates an increase of variation as the direct result of external influence: the inheritance of acquired characteristics.

Another case of unusual adaptation amongst fishes is provided by a deep-sea fish from the Indian Ocean. The eyes are on the ends of long slender stalks, projecting from the sides of the head.

To have eyes upon stalks is no exceptional thing, though rare amongst fishes. Everyone has seen the common snail extend his horns, and seen the eyes extruded at the very end of those long stalks. Many of the tropical crabs have their eyes on the ends of stalks. In some cases both eyes and stalks fit into little grooves on the crab's back and they can either lie in these groves or can be raised up to an erect position. I have seen hundreds of such crabs walking on the beaches of the islands in Shark Bay. In the evenings they come out of their holes and walk about on the sands. Usually they have their eye-stalks erected, so that they can see the better, but if they are frightened by any sudden movement, they flip their eyes down into the prone position, where they fit into the grooves provided for them. A sudden movement will frighten a whole army of such crabs, and down will go all their eyes in a communal wink. Then in a few moments up will be raised the stalked eyes once more, and the crabs will scuttle off as fast as they can to a safer place.

Snakes' eyes appear to be always open, but are, in fact, always closed. The eyelids, which are in the lizards separate, have in the snakes become fused together and have become transparent, so that the snake can see through the closed lids. The lids are closed, and so form a screen before the eyes, a protection to the organs of an animal which must, owing to its lack of limbs, move close to the earth and in the dust. There are some genera of lizards which show an interesting intermediary stage between the normal lidded condition, as shown in most lizards, and the closed, transparent eyelids of the snakes. These lizards, the skinks, have an enlarged lower lid which in some species is partially transparent. When the lids are closed, the lower lid covers the eye, protecting it, and yet the protected eye can see through the window in the lid. In other species of skinks, the edge of the lower eyelid is completely fused to the smaller upper eyelid. These lizards, like the snakes, cannot open their eyes, and like the snakes they can see through the transparent lids. The only difference in the adaptation is that in the snakes all trace of fusion between the lids has disappeared. By this we see that both the snakes and the lizards have met in the same way the problem presented by living close to the earth. An adequate device has been found to keep the dust out of their eyes.

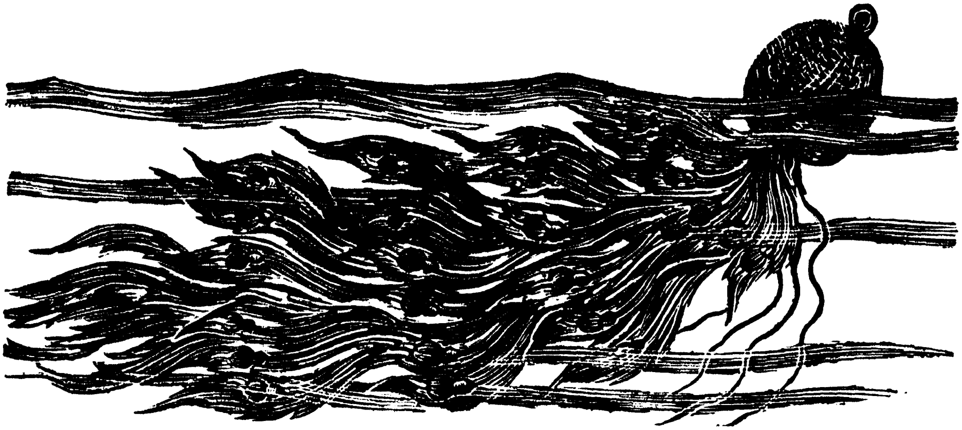
Snakes and lizards are not the only creatures which have been troubled with this problem, though it is they who seem to have met it in the most efficient manner. Earth-burrowing mammals, such as the mole, instead of growing transparent lids and so shielding their eyes, have taken the less enterprising course of giving up trying to use their eyes, or only using them a very little. The European moles have small, vestigial eyes which appear to be almost if not quite functionless. They have no eyelids, and the eyes, which are very small, seem to sit upright amongst the fur, tiny black vesicles on a thin stalk. These eyes, it is assumed, have atrophied through long disuse; and certainly it appears that the mole when on the surface of the earth is quite blind. The Australian marsupial mole, which does not live in damp burrows like the European mole, but swims its way through dry sand just beneath the surface, has no eyes at all and no eyelids.

Besides the eagles and the hawks, there are many creatures which have highly developed and very beautiful eyes. All the ostrich tribe have large, liquid and intelligent eyes and are quick- and far-sighted. Of mammals perhaps the most remarkable of all eyes is the giraffe's: a dark and luminous pool, fringed with long black lashes; but a camel's run it very close. A horse's eye can also be very beautiful and full of expression; so too, in a very different way, can be a cat's; the cat's eye, which can see in the dark, and whose pupil can close in the sunlight to the thinnest longitudinal streak.

The whale, though it is so enormous in bulk, has a small eye, no larger than that of a horse. Between the eyes, which are set far apart, one on each side of the head, is all the thickness of neck and body, which completely shuts off one field of vision from the other. The whale must constantly have two visual pictures presented to its consciousness. This must certainly be very puzzling, unless it possesses some co-ordinating process of which we know nothing. Such an animal would, without some such co-ordinating process, find it very difficult to adapt individual movement to two different and distinct pictures of the world. It may be suggested that the *Anableps* also has two different and distinct pictures, one above water and one under. Perhaps it does, but it is more probable that it regards either one or the other, at any particular time. The separate eyes operate in, and enclose, the same field of vision. The whale, on the other hand, must, all the time that its eyes are open, gaze in two *opposite* directions. It sees two separate worlds always separated by the thickness of its own body.

That eyes should be the most expressive of features is not strange when we consider that it is these organs which receive and register the light, and with the light the consciousness of the things which light illuminates. From this consciousness must come, if not at once, yet ultimately, judgment; and with judgment, memory and forethought. Eyes are in themselves expressions of personality, either of species or individuals, and as such are significant of what these personalities have, through the operating of their own functions, achieved. The possession of eyes marks in the biological world the difference between those who can see and judge, and those who must still progress through the mere opportunism of trial and error.

In both animals and men, eyes as organs of physical vision have probably reached their perfection; and amongst men, sight, the most highly prized of the senses, is taken for the symbol of yet further consciousness. We often speak of *vision*, meaning a supersensual perception, though in respect to such perception the majority of us feel ourselves to be blind, like the worm, to that light which must, with our increasing development, illuminate our consciousness. Like the worm we move by trial and error, as the crudest opportunists, seeking immediate advantage, and without the larger plan that vision would give. Our poets and our seers, prophesying of supersensual illumination, are comparable to those primitive creatures whose pigment spots can but distinguish light from darkness. The objective universe of the spirit is as yet unknown to science; only the 'unscientific' philosophers have dared as yet to suggest its existence.



Composite Animals

Amongst the simplest of living things are to be found organisms, compounded of separate living elements, which elements are able, in slightly different arrangements, to exist in other numerical associations, or as free-living individuals. Such a creature is *Pandorina*, a free-swimming colony of sixteen or sometimes of thirty-two cells, each with two flagella, or fine whip-like processes, an eye-spot, a nucleus and with chloroplasts, which are specially modified masses of protoplasm containing chlorophyl, by which the organism can take carbon dioxide from the air dissolved in water, and from this, in the presence of sunlight, form sugars and starch. Sixteen or thirty-two of such cells, enclosed in a cellulose envelope, form a single free-swimming *Pandorina*. In such a colony the flagella of the separate units are directed outwards, and are free to move in the surrounding water in which the colony lives.

Cells which are similar to the contributing units in *Pandorina* are also found living independently, and are named

Chlamydomonas. *Chlamydomonas* is the same in form and structure as the cells in *Pandorina*. The only difference is that the *Chlamydomonas* unit is free and independent of other cells, and the elements in *Pandorina* are united in a containing wall to form a small colony.

Another arrangement of such cells is found in *Pleodorina*, where a larger number of individuals of the *Chlamydomonas* type are associated within a containing cell-wall. Certain of these cells are capable of development into sexual individuals, some growing larger and constituting the female gametes, and some splitting up into a number of smaller male gametes. Others, on the other hand, remain small and do not split up, these are termed the somatic units, as opposed to the reproductive units. Another member of this group of organisms is *Volvox*. In a single *Volvox* colony is a large number of cells. The colony is sub-spherical in shape, with the individuals placed on the periphery with the flagella outwards, as in the other colonies. As in *Pleodorina*, individuals are specialised for different functions, the majority being small and somatic, and some few being developed into large female gametes, and some dividing up into a number of male microgametes. Besides reproducing sexually, *Volvox* reproduces asexually; certain individuals forming small daughter-colonies inside the parent colony.

The individual cells, all of the *Chlamydomonas* type, which form these colonies, are separated from each other, within the colony, by mucilage and by cell-walls, and are connected, one with another, by protoplasmic strands, traversing the mucilage and passing through the cell-walls. In these groups or cell associations we have an example of composite animals: individual cells associated together in groups, in which some of their numbers undergo special modifications, but others of which, and the majority, remain typical to the *Chlamydomonas* individual, which is free-swimming and independent of any association. Each separate member within the colony behaves in accordance with the ends beneficial to the life and well-being of the whole. What influence it is that controls this orientation towards a common end, and creates an harmonious differentiation within the colony, we do not know; we can but watch this process through which potentially free-living cells group themselves into larger more complex bodies at the sacrifice of their individual freedom. And as we watch, our imagination is stirred. Do we see, in the grouping of these individual cells, what is perhaps one of the simplest material manifestations of a universal impulse, one which finds other and more complex expression in all living things, and even perhaps in all things in the universe whether living or inanimate? And what, we are forced to ask, is the individual? Are we to consider the single free-swimming cell as the individual, or the complex colony with its sexual and asexual methods of reproduction?

Other more complicated organisms offer further examples of composite animals, made up of numerous units combined together to form a larger, more comprehensive whole, and one which contains all the contributing activities within its composite life. There are colonies of polyps which are related to the sea anemones, which grow upon branches, and which are connected one with another, and have a common tubular connection linking up all the separate units. Some of these units are typical polyps, rather like a simplified sea anemone, with tentacles and mouth. These function as eating individuals, catching small creatures that float by in the water, digesting them and passing on the products of digestion to the common stem. Other individuals do not make any effort to feed themselves, but derive their nourishment from the food procured by the active polyps. The latter are modified for reproduction. In some species the reproductive units are budded off in the form of small medusae, which medusae float free from the parent colony, produce male and female gametes, which are shed into the sea, and there unite to form fertilised eggs. The eggs, settling upon rocks or seaweed, form new branching stems, from which new colonies arise. In such creatures we find a number of individuals combining, in a branched, plant-like structure, to form a composite whole made up of a number of different parts, each of which displays many qualities of other free-living individuals. The polyps in such a colony as *Obelia* are comparable to the individual sea anemones, and behave in much the same way; the medusae are comparable to free-swimming jelly-fish: they are capable of feeding themselves, once they are detached from the parent stem, and they have also the power of sexual reproduction. Yet these partially manifesting individuals may well be considered as organs of the larger, containing colony—organs which in some cases are detached, and wander far in space from the creature of which they are essentially a part. Again we are presented with the question:

What exactly does the word individual mean? I shall make no attempt at present to define this ambiguous term, but will first consider other cases of composite animals, and will then contrast the life of such creatures with the life of other colony-forming animals.

Colonies formed by yet more complicated associations of individual units are offered by other members of the *Coelenterate* order. The Portuguese men-of-war, which anyone who has sailed down the west coast of Africa cannot have failed to observe, are groups of highly modified polyps, all living together, and functioning in their own peculiar way for the common benefit of the colony. Each Portuguese man-of-war consists of one large cap-shaped float, under which the other units are clustered. This cap-shaped float is itself a highly specialised polyp, and in its earlier stages is seen to resemble the typical archetype hydroid. Under the float are grouped the other members of the colony; these consist of two different types of tentacles, each developed and highly specialised from the primitive hydroid. The shorter tentacles are arranged under the edge of the float; the others, which are very much more elongated, hang down in a kind of drift-net to catch whatever comes their way in the form of eatable food. So strong are these catching-organs, or catching-individuals, that they are able to capture and hold a full grown mackerel. They can poison their prey with their stinging cells or nematocysts, and so virulent is this poison that it can endanger human life.

The tentacles, once they have secured and poisoned what they have caught, contract, bringing the food close under the float, into that region where those other individuals, specialised for sucking and digesting, are situated. These fasten upon the food with their many mouths and take the nourishment which supports the whole colony. The nutriment is passed along the tubes which connect every portion of this composite animal.

Besides the two separate forms of the predaceous individuals and the feeding individuals, there are other units specially modified for reproduction; these are situated well at the base of the feeding individuals, and in the most protected position possible under the bell-shaped float. These, of course, do nothing but produce the sexual cells, and are like other sexual organs, parasitic on the organism. They are in this case fed by the food caught by the predaceous units and digested by the feeding units.

In this composite animal, we see how the different units all work together for a common end, the well-being of the colony. They are united into a whole and fed by a common liquid, and supported by a single umbrella-float, which is one of themselves, modified for this purpose. Compare such a united group of modified individuals with *Volvox* and we see that the differentiation has gone further, and that the component units are more specialised for their functions, though they are yet united in one bodily whole. But compare it also with quite a different form of composite animal, a nest of termites.

Amongst the termites, we find a number of individual insects all working together for a common end. We find the queen termite and her mate, deeply hidden and well protected in the middle of the nest. The queen termite is highly specialised for the laying of eggs. Her abdomen is immensely swollen, and her short weak legs can hardly move her body. The king, her husband, is smaller than she is and more agile, but too large to get through the passages through which the workers can approach and leave the royal chamber. The workers are very much smaller, about ·4 cm. in length as compared with the queen's six to seven centimetres. They may be regarded as termites which have remained in the larval stage. They are usually blind and without reproductive organs. Their mandibles are well adapted for gnawing wood, and their chief function is to gather wood débris from outside the nest, to fill their intestines with it, and subsequently to use the ligneous paste thus produced for the manuring of fungus gardens, which are made in the lower and central portion of the nest. Their duties also include the building of the nest, the arching of the tunnels to keep their tender bodies protected from the ants, also the tending and feeding of the king and queen, and the transporting of the eggs. The workers are very numerous and well adapted for their many tasks.

The soldiers are larger than the workers, ·83 cm. long. They are more specialised and further removed from the sexual form. The soldier's head is hard and elongated, with sickle-shaped mandibles, ill-adapted for gnawing wood, but admirable weapons of offence or defence. The soldier's task is to defend the colony against ants, millipedes and other creatures, and its courage is proof against all trials. The soldier does not work at the collecting of wood-pulp nor at the cultivating of fungi.

In the termite colony the differing functions of the individuals are well marked: the king and queen, purely reproductive, the queen laying as many as 30,000 eggs a day; the workers are horticultural and mechanical, and the soldiers defensive; all are united by the guiding spirit of the colony, and each member performs its function with the regularity and precision of an organ, functioning within the body of the whole. If danger threatens, an instinctive response is made by the differently modified individuals, and this response is always adequate to the occasion. Professor Bugnion in his book *The Origin of Instinct* describes the resistance made to ants by termites when a hole was artificially made in the termite nest.

'Some very agile ants scenting good fortune were soon on the spot. Forcing their way into the chamber, they seized the young larvae and stole away as quickly as possible, carrying their prey. As soon as they received warning, a multitude of soldier termites rushed up. Organising the defence, they arranged themselves in a circle all round the opening, opened their mandibles and offered resistance to the ants. The workers for their part lost not a moment in getting to work. They brought up little slabs of earth from the interior of the nest, moistened them with saliva, deposited them at the surface of the fungus bed, and began to construct a system of pillars. In half an hour's time a sort of lace pattern could be traced, formed out of damp earth. This lacework of earth was the first sign of an operculum which was to be propped up on the pillars, leaving no sign of an opening. A crack several millimetres broad, like a miniature trench, round the principal wall and the edges of the operculum, were occupied by the soldiers, which remained in circular formation all the time and opposed themselves unflinchingly to the invading ants. Remaining firmly at their posts, and protected by the trench in which they sheltered, they kept good watch until all danger was passed.'

This description shows clearly how the different types adapted themselves in a perfectly adequate manner to the emergency, each worker contributing to the complicated architectural task of building up a comparatively large operculum, and the soldiers assuming a military disposition competent to keep out the invaders. Such an instance is but one of many, and it is well known how that in hives of bees or nests of ants, an order, issued in some unknown way by the corporate body of the colony, can be taken up by each individual as though that individual unit were sensitively in touch and incorporated in the will of the whole. Again the question may be asked: What is an individual? The hive or nest, or the unit lives of which it is composed?

There are other aspects of this question, where the relation between corporate whole and the component parts are not so significantly defined. The starling when in the spring it takes to itself a mate and builds a nest, behaves very much as an individual bird. (Since the word individual is under question, I should say: what we are accustomed to think of as an individual bird.) In the autumn when the large flocks are formed, then the starling behaves in some respects as though it were governed by some powerful and precise influence, which we can only speak of as the spirit of the flock. When the starlings are flying together in large numbers, each bird flies in accordance with the general flight of the flock. They do not copy each other, but often move instantaneously in the same way, every wing deflected or raised at the exact fraction of a second, as though the muscles and nerves were governed by some master nerve which was the attribute of the community, of that larger, psychic reality which was the starling flock. Then each bird behaves as an organ behaves, contributing to the movement and rhythm of the whole.

Not only in the movement of individual flocks, but in the movement of many flocks is this mysterious influence made manifest. Why should all the fishes of a certain species turn to migrate at the same time? Why should migrating birds follow each, according to its species, its line of flight, not by any means the shortest or most reasonable route to the desired locality? Is there not indicated by this behaviour some larger invisible reality binding these creatures together and making them one within the larger individuality of their species?

From these unanswered questions we are led farther, unless imagination slumbers. If we have ever looked with contemplation at any animal—a dog, a cat or a duck—does not a prolonged scrutiny of its form, its nature and its specific sounds tell us of something beyond its material body? Do we in the dog which we know so well see an *individual* dog? He may have peculiarities of his own, but is not the essential quality of him a thing not pertaining particularly to himself, but to all dogs? He would seem rather, to that look of prolonged contemplation, to be but a partial expression of that dog-soul, inhabiting the bodies of all dogs, and imposing on them its larger individuality in habits of behaviour, which in the most strictly trained and domesticated dogs remain ineradicable. An animal shares with all others of its species those experiences which would constitute its destiny; in the things which happen to it, and in its reaction to those happenings its species can be recognised. In this way it lacks that individuality which human beings claim to be their distinction and their most highly valued quality. The species may well be thought of as containing, what the separate units of the species lack, namely that unity, compounded of the attributes and characteristics of its many members, which defines an individual destiny.

Is then, we may ask as our last question, an individual that living creature whose destiny is within its own power to control, a creature which not only perceives as animals perceive, but knows and judges, and knowing and judging, can by its will separate itself from the objects which it perceives, and, to a certain extent, liberate itself from their influence? In so far as it can do this, it is free of the stresses and strains which constitute the ever-changing flux of the surrounding universe. If man is such a creature as this, then by that power he attains to a nature which can say: 'I, as subject, exist by the grace of my thought. Thought takes me out of myself, and relates me to objects. At the same time it separates me from them, inasmuch as I, as subject, am set over against the objects.'[1] If, and when he is able to say that, he attains his unique distinction amongst the animals. His thought then embraces himself and the rest of the

[1] *The Philosophy of Spiritual Activity*, Rudolf Steiner.

world, and by that same act of thought, he determines himself an individual, in contrast to the objective world from which he is separated.

Should such be the conditions which distinguish individuality, how much do we as human units attain, and how much do we remain under the compulsion of the objects, and part of that unconscious, unknowing, unjudging composite creature, whose individuality, like the animal's, remains elsewhere, and which in past and present history constitutes the corporate man?

Exceptional Sensibilities

In early spring, towards the end of February, the Kentish Glory moth emerges from her cocoon, which has lain during the winter amongst dead leaves close to the ground. By short flights or by climbing she reaches the terminal twigs of silver birch trees. On these, after impregnation, she lays her eggs. As yet there is no sign of a leaf on these bare twigs, yet the moth, provided she is free to go where she will, seldom makes a mistake as to the tree on which she lays her eggs. Were she to do so and lay her eggs on any other kind of tree, or upon any portion of the tree but the twigs, then the young caterpillars when they emerged would not find the leaves on which to feed, and would not have the strength to walk so far as to find them. In order that these unseen, unknown offspring should survive, the mother moth must place her eggs in the right place, namely on the terminal twigs where leaves will be easy to find. The moth cannot know that the bare February twigs are going, long after she is dead, to put forth leaves, yet she invariably places her eggs in the right place. Some exceptional sensibility must communicate to her the rightness or wrongness of her environment in relation to her egg-laying. She must be sensitive to some radiations given off by the birch twigs. In the same way that the wireless apparatus is sensitive to certain etheric waves, so it might seem possible that the moth is sensitive to other waves, of far different length no doubt from those received by the wireless set, but waves which will one day be measurable, which are sent out by the birch twigs.

The Kentish Glory is not exceptional in this capacity. Many other moths and butterflies, and many other kinds of insects also are able to select the right environment for their young without having any knowledge of what their young are going to be like, or of what their needs will be, and it is possible, if not definitely probable, that a great deal of what has hitherto been called instinct may be accounted for by a mechanism which is sensitive either to atmospheric or etheric waves. It is well known that the male moths of certain species will assemble from great distances to find the females. Henri Fabre carried out many carefully checked experiments on the Great Emperor moth and the Oak Egger. He records how hundreds of male moths came in the course of a few nights to visit one female. Neither the Emperor moth nor the Egger were noticeably common in his locality, yet these large numbers of males found their way from distant places to visit the females confined in his study. They must, most certainly, have received some kind of message. When the females were confined in an air-tight box, the males were not attracted, yet the message: 'Female moth of my species' which the males received was not in the nature of scent, for no strong covering scent could obscure it, and moreover it was found to travel up wind and not down wind, as would be the case of an air-borne scent. How this message is conveyed no one yet knows; we only know that it must exist, or the male moths would not respond as they do.

It has been supposed that the antennae of insects are sense organs of an exceptional kind. And anyone who has watched an insect, such as a locust, waving its long antennae in the air, is easily persuaded to believe that these sensitive-seeming organs must be capable of feeling and of communicating messages to their possessor. The fact that the male moths of such species as the Emperor and the Egger have larger and more dentated antennae than the females, would lead one to suppose that the males were provided with more sensitive organs, and for the purpose that they might seek out the more heavy-bodied and less mobile female. Fabre experimented by removing the antennae of the males, but came to no definite conclusion as to whether or not they were the organs that sensed the locality of the female. It is known, however, that the antennae of insects always carry hairs, and that these hairs have in some cases an olfactory function. In such cases, if the antennae are removed or coated with wax the sense of smell is largely destroyed. The Egger and the Emperor moth do not scent the female in the sense that we use the word. One scent can be obliterated by another, as witness that of a fox that runs through a flock of sheep; but in the case of the moth no amount of fumigation can keep the males from finding the females. They possess some extraordinary sensitiveness which is unknown to our perceptions, and can pick up not only the emanation given out by the female but the emanations which remain lingering about these places where she has lately been sitting. Fabre found that the moths would go more readily to those places where the female had been resting for some hours than to the female herself, when she had but recently taken up a new position.

The skin or the chitinous outer covering of many of the lower animals is in all probability sensitive in a way, or in ways, about which we know very little; not only the antennae of insects are distinguished as specialised centres of sensation, but many of the hairs with which their bodies are covered are highly sensitive, and some species of spiders are provided with curious emergences from the lower portion of the thorax, which are believed to be sense organs, though what their actual function is, is yet unknown.

The naked skin of higher animals or naked patches of skin are usually very sensitive. Frogs and toads are quickly aware of any coming change in climatic conditions, and even human skin, once it is given opportunity to function in the open air, develops many subtle sensibilities which are unknown to the normal clothed condition. The perceptivity of the stretched membranes which constitute the wings of a bat offers the most remarkable example of an unusual sensitiveness. The impact of currents of air upon the wing is sufficient to indicate to those acutely perceptive organs the nearness of any objects which may be contributing to the production of those currents. To demonstrate this extreme sensibility bats have been blinded, and then released in rooms where numbers of impedimenta in the form of wires have been stretched about and across the flying space. The bats although blinded and unable to see the wires or other objects, have been able to avoid flying into them by the sensitivity of their wings to the nearness of the objects. Even in that fraction of a second as the wing approached, they have felt the presence of something near by and the stimulus has been sufficient to enable them to so alter the stroke of the wing as to avoid the obstacle.

Another organ of sensitive perception about which little is definitely known is the tongue of a snake. Some naturalists, and W. H. Hudson amongst them, have maintained that the serpent's tongue is no sensitive organ, but is used either as a lure or a warning. To many others it seems to be an organ of sense, and so it appears to me. Ruskin has written: '. . . we've got to ask the scientific people what use a serpent has for its tongue, since it neither works it to talk with, or taste with, or hiss with, nor, as far as I know, to lick with, and least of all, to sting with—and yet, for people who do not know the creature, the little vibrating forked thread, flicked out of the mouth and back again, as quick as lightning, is the most striking part of the beast; but what is the use of it? Nearly every creature but a snake can do some sort of mischief with its tongue. A woman worries with it, a chameleon catches flies with it, a cat steals milk with it, a pholas digs holes in the rock with it, and a gnat digs holes in *us* with it; but the poor snake cannot do any manner of harm with it whatsoever; and what is *his* tongue for?'

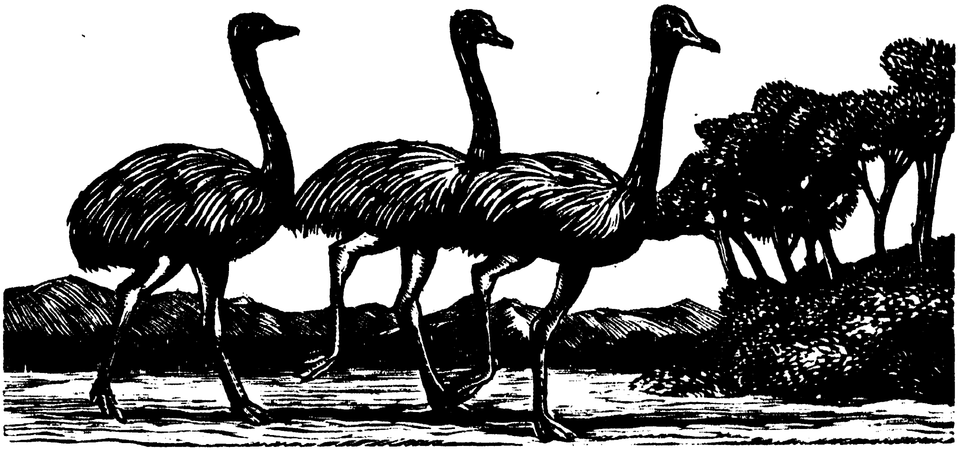
For my own part, I have no doubt as to how I should answer Ruskin's question. I have watched many snakes both wild and in captivity, and I find it hard to understand how anyone who has closely observed the use of this organ can fail to see it as anything but a sensitive instrument feeling the air, *licking* the air, and each time that it withdraws into the mouth coming back with some message from the outside world. Hudson says that he has never seen a snake touch earth, rock or leaf, or anything whatsoever with its tongue. Consequently, he concludes, the tongue is not a tactile organ. He is wrong in saying that snakes never use their tongues for licking. On one occasion I have seen an Australian death adder licking a piece of dead grass stem and continuing to do so for some minutes. Why it was licking the grass I could not discover, but most definitely it was licking the grass with its finely-forked tongue, and appeared to find satisfaction in the act, for it returned after several short rests to continue those delicate and swift strokes with which its tongue seemed to caress the grass stem. And as a snake will on some occasions lick definite objects, so, I believe, it licks the atmosphere, feeling the quality of air as the bat's wing feels currents in the atmosphere. It turns its head towards the object of its attention, then out will flash that forked thread of a tongue. As its interest or excitement becomes greater, or when danger threatens, the tongue becomes very active and the intervals between its extrusions will become shorter. Hudson in his essay on the serpent's tongue argues that this flashing in and out of the tongue is a necessary part of the creature's peculiar strangeness: 'The long, limbless body, lithely and mysteriously gliding on the surface; the glittering scales and curious mottlings, bright or lurid; the statuesque, arrowy head, sharp-cut and immovable; the round lidless eyes, fixed and brilliant; the long, bifurcated tongue, shining black or crimson, with its fantastic flickering play before the close-shut, lipless mouth—that is the serpent, and probably no single detail in the fateful creature's appearance could be omitted and the effect of its presence on other animals be the same.' That is a wonderful and memorable picture, but it should be remembered that lizards, whose tongues are not so slender as a snake's, nor so deeply forked, are also used in exactly the same way, the tongue comes flicking in and out, feeling or licking the air. Lizards are not such 'fateful' or 'mysterious' creatures, and yet they have the same habit and, I believe, their tongues have in all probability the same function. They are neither used as warnings nor as lures, but as organs of sense, testing the atmosphere, though how precisely they function we do not know.

An organ of a quite different nature, yet probably possessing an exceptional kind of sensibility, is the lateral line possessed by most fishes. The skin is probably sensitive all over, since it is supplied with the terminations of sensory nerves; these are spindle-shaped bodies and are irregularly distributed all over the body, and in the mouth and pharynx form the organs of taste. The nerve terminations in the lateral line are similar to these, but are usually sunk beneath the skin and contained in grooves or in closed canals. In all cases they are developed on the surface of the body and subsequently enclosed by up-growings or overfoldings of skin. The lateral line is in most cases a tube which reaches from the base of the head from the auditory region along the side of the body to the root of the tail. Along the length of this tube there are at regular intervals openings to the exterior. The nerve endings are in the skin which lines the tube; they derive from a branch of the tenth cranial nerve, which runs parallel to the tube and sends small branches off to each sense organ. In some fishes this tube will have extensions which run over the head in branching lines; they radiate from a focus formed by the auditory organ, which may be regarded as an enlarged sense organ of the same system.

Although it has long been recognised that the lateral line constitutes a system of sense organs, it has been difficult and still remains difficult to know exactly how it functions. Experiments have been devised to try and find out what influence this system of organs has on the life of the fish. The nerves supplying the lateral line have been cut, and also those nerves supplying similar organs in the head. The behaviour of fishes thus operated on has then been compared with normal fishes. Very little difference was to be observed. Mr. G. H. Parker, who was carrying on these experiments, found that fishes whose lateral line nerves had been cut were not sensitive to certain low vibrations in the water which normal fishes responded to, and that the fishes that had been operated upon were in some other ways less sensitive. For example, if the surface of the water were blown upon and strong ripples produced, then the normal fish would go invariably to the bottom, whilst those with cut nerves would only sink a little way in the water. If objects were moved in the water close to the fish, in such a way that the fish could not see them, then the operated fishes were less sensitive than the normal to these disturbances. It would seem from this that the lateral line system of organs was for the perceiving of the movements of other fish or creatures moving in the water.

In a book dealing primarily with the peculiarities of animals, there is no space to deal at all adequately with all the extraordinary or unusual sensibilities which can occur in human beings. The testimony to such extraordinary sensibilities is often of an ill-substantiated nature, and lacks, on account of the very nature of its sensitivity, the controlled experiments which scientific exactitude demands. Of such experiences a large literature exists, under the headings of psychology, religious experience and under various forms of spiritualistic phenomena. Such experiences demand, with an increasing urgency, further open-minded investigation, but in this book there is no place for them, nor do I wish to recount the various stories of telepathic sympathy between dogs and their masters, or even those stories of the extraordinary homing-instincts of domesticated animals. One human experience, however, I will describe, as it bears directly on the sensitivity of the human skin, and reveals a faculty which in civilised man is usually dormant and unsuspected.

An officer in the English army, fighting in East Africa during the Great War, gave me this account of his experiences. As a commander of a small patrol, it was his duty to keep in touch with other similar small bodies of men. This was often difficult as posts were far apart, and contact was only occasional in very wild country. The nights, when there was no moon, were very dark, and often when enemy patrols were suspected to be in the neighbourhood no light could be shown. On such dark nights, the men would listen to the lions roaring, and would notice that after a period of loud roaring, getting nearer and nearer, there would be silence. When the silence came, they believed that the lions were close to them, and were either stalking them or some other prey. During this silence, my informant and his companions would all suffer from severe shivering fits, which they could not control, and which they found very annoying, as suggesting the mark and sign of an uncontrollable fear. My friend had the idea that this humiliating shivering might be stopped by the wearing of a great-coat. Whether because shivering is usually associated with cold he had this idea I do not know, but he and his companions were far from cold. The nights were extremely warm and the heavy coats very irksome. The wearing of coats had the desired effect, and my friend ordered that his men should always, on such occasions, wear theirs. Though they were hot and uncomfortable, they did not shiver. His belief, and I think it was a reasonable one, was that the almost naked body, clad only in thin shirt and pants was sensitive to the nearness of the lions, and that shivering was an involuntary reaction. When the men wore their great-coats, although they suffered from the great heat of the tropical nights, they were not affected by the unwelcome shivering, which appeared as a sign of fear, but was in reality a response to that sensitivity of the skin which apprehended the nearness of the lions.



Degenerate Birds

Though evolutionists find it difficult to point to any bird, living or extinct, which is provided with fore limbs which may be considered as being in the process of developing towards wings, there is no question that there are many birds which possess vestigial or degenerating organs of flight. The theory put forward by evolutionists is as follows: The ancestors of birds were creatures which, at first, scuttled along the ground, and which used their fore limbs to beat the air with, and so quicken their pace. Later, those which went the fastest were, owing to the action of natural selection, able to increase the advantage thus gained. In the course of generations they were able to take larger and larger hops, which, in time, resulted in glides, and finally in flight. This theory has no recorded facts to support it. Wings, when they are found, are found as wings, as complete and adequate mechanisms, and not as stumps or flappers. The stumps or flappers which are possessed by living or extinct birds mark various stages of devolution from earlier winged forms. Their possessors are loosing or have lost the power of supporting themselves in the air. There are many instances of birds with degenerate wings.

An example of such degeneration in state of process is afforded by the South American logger-headed duck. This bird can fly when it is young, but its wings are too small to support it when it grows older and heavier. It then uses them as auxiliary paddles to help it scuttle along over the surface of lake or pond.

The most remarkable and best-known group of flightless birds are, of course, the ostriches. These birds are well adapted for running over desert or steppe land; their extreme length and heaviness of leg would alone, quite apart from their lack of pectoral muscles, make it impossible for them to fly. They use their wings spread out on either side when running; these help to give them balance, and often give the appearance of small sails spread before the wind. Darwin, in his *Journal of a Voyage round the World*, gives an account of the rheas or South American ostriches. These birds are to a certain extent parasitical, as Darwin expresses it, on each other, in that they lay eggs in each other's nests. In this respect they are like the cuckoos, in that they employ foster parents for the incubation of their eggs and the tending of their young. Like the cuckoos the hen birds lay their eggs at comparatively long intervals. The hen rhea has an interval of three days between the laying of the eggs. She lays in all from twenty to forty eggs (some authorities say as many as seventy). If she were to attempt to incubate these herself, those which were laid first would probably be addled before the latter ones were laid. She does not, however, try to incubate all her own eggs, nor does she lay them all in the same nest. Two or three females associate together at the nesting season, and place a large number of eggs in one nest, and they also seem to lay very carelessly and drop a certain number of eggs haphazardly in the neighbourhood. A male bird associates with each group of females, and he takes upon himself the task of incubation, and also he will collect a number of the chance-laid eggs and bring them to the nest. He will then sit upon the eggs and hatch them, and subsequently undertakes the care of the young chicks. The hen birds, which have not yet laid their full quota of eggs, will then move on, leaving the cock bird to his task of incubation, and will look out for and find another cock bird; they will make another nest, in which they will lay, and which in its turn will be taken charge of by the cock. In this way a fair proportion of the eggs will be incubated while they are still fresh.

This method of egg-laying and egg-incubation shows an extraordinary adaptation to the realities of the situation, namely the slow egg-laying propensities of the hens and the large number of eggs laid by each hen. The numbers of the sexes are approximately equal. If we suppose that three hens club together in a group for the laying of eggs, then when they have between them laid the first forty eggs, they will move on, leaving a cock bird behind them to accomplish the incubation. Another nest is formed and another cock is found for the necessary task. By the time the third nest is made and a third cock is established upon the eggs, the hens will have laid their full quota of eggs. In this way an equal number of the sexes have been occupied in the business of reproduction.

But in actual life, the economy is not so perfect as it would appear in this suppositional case. Varying numbers of hens join together for their nest making. Sometimes they seem unable to find a cock when he is wanted. They are very careless in their egg-laying, sometimes laying in the nest, but often dropping their eggs at hazard. In this way a lot of eggs are wasted, although the cocks are known to collect these stray eggs and bring them to the nests.

The African ostriches, though larger and different in several respects from the South American rheas, have the same method of egg-laying and incubation. Both species demonstrate the same curious economy, which would appear to be determined by the fact that the females lay a large number of eggs at considerable intervals. The instinctive behaviour of both the cocks and the hens is in harmony with the conditions of their life; yet the harmony is by no means perfect, for, like the rheas, the hens are notoriously careless in the laying of their eggs, and often drop them too far distant from the nest for the cock to be able to collect them and bring them to the place of incubation.

Some naturalists have suggested that the stray eggs are later found by the young birds and eaten; this seems very improbable, as these stray eggs are usually found to be putrid and with unbroken shells.

The emu, a bird resembling the ostrich in many respects, has also degenerate wings, which are not able to be folded and which are altogether covered up by the hair-like feathers. Their nesting habits are similar to those of the rhea and the ostrich, in that the male bird collects and incubates the eggs. I have found emus in their native state to be very inquisitive and at the same time very shy birds. They are much hunted by the aborigines, who are very fond of their flesh when it has become sufficiently high for their strong palates, consequently the birds are hard to come near. I have found, however, that when I have been sitting quite still in the bush (it is always a good plan to sit still if you want to see things) the emus have come to look at me. With a small piece of looking-glass I have managed to excite their natural curiosity to such an extent that by flashing the sunlight in the mirror and directing it in the neighbourhood of the emu, I have persuaded birds, on several different occasions, to come within a few feet. This experiment on their curiosity besides being amusing and interesting, was also exciting. To see this large, imposing bird first make its appearance amongst the blue, feathery-leaved mulga bushes was always an event. I never actually *saw* one come into my field of vision, it was suddenly there, having approached so quietly that I had not noticed it. With the least possible movement I would flash the mirror. In a few moments the bird would come closer, and stretch out its long neck with the same enquiring expression as a hen. Another flash, and it would come nearer, nearer, nearer, until I could see the large bright eyes which look so intelligent under that flat, unintelligent forehead. The nictating membrane, a kind of shutter of blue skin which goes across the eye from time to time, I have always found fascinating to watch. It never fails to evoke in me an impression of the unexpected and bizarre, to be followed immediately by a return of that bright-eyed stare, and an as-you-were look, as of a conjurer completing his trick.

I have brought emus so near me by this device of the looking-glass, that I have been afraid that they might peck. When at last I have moved, how they have jumped with surprise and raced away for safety!

I have not myself ever been fortunate enough to find the eggs. Like the ostriches they are often careless in their laying, and odd, solitary eggs are frequently to be found lying about. Once I was in the bush with a native boy, and noticed the footmarks of an emu, and was foolish enough to point this out (it was not an easily seen mark) to the native. 'Emu', he said with a grin, 'and twelve pickininy.' He held up hands and fingers to show the numbers.

After some questioning I found that his quick eyesight had seen in the dust the footmarks of young emus, and not only had seen these small marks, but had perceived that they were made by twelve *different* pairs of feet. These little feet had been moving to and fro, and up and down, and crossing each other's trails many times, yet the man said with confidence: twelve little ones. It seemed to me unbelievable that he should be able to gauge the number. It was as though a man should look at the dust in an empty chicken run and should say how many had been there. I asked how far away they were. Not very far, he said. I told him to find them, and in a short while, by following the tracks, we came on a parent bird and, as he had said, twelve chicks.

The kiwi or apteryx of New Zealand has even less of wings than the emu, and its feathers are even more hair-like. It is smaller and lighter than an ordinary barn-door fowl, yet it lays an egg weighing as much as fourteen and a half ounces, as against the fowl's average production of two and a quarter ounces. Seldom does the hen kiwi lay more than two, and even then the cock bird has considerable difficulty in covering them. These little creatures, which are now almost extinct on the larger islands, though they are protected and preserved on some of the small islands, have other qualities besides their absence of wings which indicate degeneration. They have a curious habit of heavy sleeping, and it is possible to pick them up and handle them without waking them. One must suppose that this habit could only have been possible in animals who had few enemies to harry them.

There are, or have been, a considerable number of flightless birds living or extinct in New Zealand. The islands are far distant from other and larger territories, and as a consequence of this remoteness, there are, with the exception of one small rat, no indigenous mammals. This absence of mammals may perhaps account for the number of birds that have taken to running on the land and have abandoned the habit of flight. Where there are no predaceous animals of the cat tribe, why should not a certain number of the birds become adapted to a terrestrial life? Whether there is any true cogency in so simple a question or not, the facts point to a replacement of mammalian quadrupeds by several species of large flightless birds. Various species of the genus *Dinornis*, some of which were as much as twelve feet high, roamed over the islands in large numbers, and only became extinct after the Maoris landed in New Zealand. Besides these large extinct species there are other smaller birds such as the kiwi; and besides such birds, which are obviously adapted to a running, scratching habit of life, there is a large parrot whose breast muscles are so poorly developed that its wings can only be used as side balancers and occasionally as gliders. This bird has taken to a night-time existence. During the day it remains hidden either in a hole in the ground or amongst the roots of trees. Only in the night does it dare to come out and seek for its food. Another flightless bird of New Zealand is the Maori hen or weka rail. In general appearance it offers no peculiar features to suggest that it cannot fly. Its wings are of considerable size, but their quills are so soft that they are unable to hold the air.

Other extinct species besides the dinornis are the dodo and solitaire; both of these are of the pigeon tribe. The dodo, named from the Portuguese word *doudo*, which means simpleton, was found living in Mauritius when the island was first discovered. The dodo was a large, ungainly bird about the size of a turkey, and appears to have been unable to defend itself against either the men who invaded the island or the pigs which the men brought with them and which soon roamed at large in semi-wild herds. Within two hundred years of its discovery in 1507 it had ceased to exist. In the neighbouring island of Rodriguez an allied species, the solitaire, existed till about 1761, but its flightlessness, which before the discovery of the island had not been a serious disadvantage, now led to its extinction.

The auks and penguins are in a slightly different category from the birds already mentioned. They too are flightless, but their wings instead of being merely degenerate have become admirably adapted to swimming; as any one who visits the new penguin enclosure in the Zoological Gardens can see for himself. Penguins in their long searching dives under water, use their wings as other birds use them in flight, and may be said to fly under water. But although they can fly under water, their wings are too narrow and small to be able to support their heavy bodies in the air. The razor-bills, which can often be seen in the sea round the English coasts, present an interesting half-way stage in this kind of wing development. Their wings, like the auks and the penguins, are admirably adapted to swimming under water, but they are not so far modified for underwater work but that they can also fly in the air. The razor-bill has to beat its wings very swiftly to be able to sustain its weight in the air.

The great auk or gare-fowl, like the dodo and the solitaire, has become extinct. These birds, which inhabited Iceland and other northern islands including St. Kilda, were exterminated by men. They were hunted for their skins, their feathers and their flesh; their flesh being used not for human food but for the baiting of fishermen's hooks. As soon as there were signs that the species might become extinct, the collectors and their agents finished the work of extermination. After having slaughtered these birds in their thousands without regard or without imagination, then, when they were extinct, men were prepared to pay fancy prices for their stuffed remains or for their hollow egg shells. As much as three hundred and thirty pounds was paid for a single egg shell! Some score or so of these relics still remain in museums, but the live bird, which lived happily enough until its defencelessness was discovered by men, is no more.

Unlikely Neighbours

There are animals which live in close association with each other and which yet seem to be the most unlikely neighbours. My attention was first drawn to this apparent neighbourliness of creatures which one would expect to be unneighbourly by the relation between foxes and rabbits at certain periods of the year. I had found a fox's earth with young cubs and had seen the vixen carrying a dead rabbit to her litter. That appeared natural enough, and I was glad that it was a rabbit and not one of my own chickens or ducks which lived not very far off. I was careful to avoid going too near the earth, for I did not want the foxes to move their quarters before I had had a good opportunity of looking at them. A few days later I went again. I approached carefully, keeping under cover. The time was about sunset, and out on a heath-covered slope lay one of the foxes. Close to her were several full-grown rabbits, running in short, rapid runs as is their habit, and sometimes giving little leaps.

What at once appeared as remarkable was that they showed no sign of fear of the fox, but ran quite close to her, and she for her part watched them with a lazy kind of interest, and not as though they were her natural prey.

After a time the game that the rabbits were playing became faster, and as they came more recklessly close to the fox, this seemed to overcome her mood of indolence. She jumped up and made a pass at one of the rabbits, but instead of trying to seize it, made a playful retreat, balanced for a moment on her hind legs, and then ran *away* from the rabbit, who quite understanding the nature of this gesture, ran after the fox; and when the fox crouched down leaped over her body; then went a short distance up the hillside and turned to thump an excited challenge with its hind leg.

In this manner they sported together in harmless playfulness while I watched. This game amongst the heather bushes and over the pale, close-nibbled grass, was within a bare hundred yards of the earth. On this occasion I saw no sign of the young foxes, which but two mornings before I had seen pulling at the dead rabbit their mother had brought them.

Why, I questioned, does the fox play with the rabbits and why are the rabbits not frightened of the fox?

This same story of foxes and rabbits playing together during the spring months, I have since heard from other people, and I have tried to puzzle out some theory to account for this strangeness.

W. H. Hudson in his book *A Naturalist in La Plata* tells of the vizcachas, large rodents about the size of a hare and great burrowers, which live on the Argentine pampas. These animals live communally in villages, each village being composed of about twelve to fifteen burrows. The earth thrown out from the burrows forms a considerable mound. In this mound of comparatively dry earth, raised some thirty inches above the surrounding plain, other animals come to live, and among these animals are foxes. A pair of foxes will establish themselves in a village by turning a pair of vizcachas out of their burrow and taking it for themselves. They do not kill the vizcachas, and after a time are accepted by the inhabitants of the village as permanent residents. They are quiet and unassuming in their demeanour, and often in the evenings sit on the mound in the company of the rightful owners. 'But in the spring,' Hudson writes, 'when the young vizcachas are large enough to leave their cells, then the fox makes them his prey; and if it is a bitch fox, with a family of eight or nine to provide for, she will grow so bold as to hunt her helpless quarry from hole to hole, and do battle with the old ones, and carry off the young in spite of them, so that all the young animals in the village are eventually destroyed. Often when the young foxes are large enough to follow their mother, the whole family takes leave of the vizcachera where such cruel havoc has been made to settle in another, there to continue their depredations.'

Now it has seemed to me that the English fox may be behaving towards the rabbits in very much the same way as the South American fox is behaving towards the vizcachas. This theory is put forward tentatively and only as a suggestion. It would need much careful and checked observation to establish it in any way; it is, as I repeat, only a suggestion, which might account for the peculiar behaviour of the fox. Is it not possible that the English fox deliberately abstains from preying upon those rabbits that live in the immediate neighbourhood of its earth? If this were so, the rabbits that are left immune from attack, could soon become accustomed to the foxes, and would, on occasions, play with them. The young rabbits, however, which are all the time being born will, as soon as they are old enough to run, be snapped up by the foxes. If there is anything in this idea, it is supported by the fact that only full-grown rabbits were to be seen playing on the hillside with the fox, and this at a time when young rabbits were exceedingly common in most other places.

The parent rabbits were no doubt too stupid to realise that their offspring were being preyed upon. What we can not be so certain about is: Is the fox wily enough to realise that old rabbits mean in time young rabbits, or is his behaviour merely one of those baffling automatisms which we meet with so frequently, and which are loosely classed under the description of instinctive action? Or is there perhaps some entirely different explanation, and is this another case of an association in antagonism such as we see in the rabbit and the stoat?

To return to the vizcachas, foxes are not the only other foreign inhabitants of their earthen villages. Birds of several species including a swallow and an owl nest in the bank-sides of the mound, and make smaller burrows into the sides of the excavations made by the vizcachas. These birds hop about or fly amongst the true architects and owners of the village, who take little notice of them. There are snakes also which habitually live in these mounds and burrows, and which appear to be, if not friendly to the other inhabitants, at least indifferent. Mice and rats and weasels and other mammals, such as the agouti, will use the vizcachas' villages rather than take the trouble to burrow for themselves. Insects of various kinds are here found more frequently than elsewhere on the plains. They are attracted by the dryer, higher ground, and so each village mound of some sixteen to twenty feet across is the centre of mixed and various life, where different kinds of birds, snakes, insects and mammals all live together in what at first seems an unlikely association; each and all benefiting in some way by the activities of the vizcachas, who with their original industry have raised the earth above the surrounding moisture of the plain, and have made the burrows which their neighbours have either usurped or augmented to their own use.

While considering these associations of unlikely neighbours which occur in natural conditions, it is of interest to remember those associations or 'friendships' which so commonly occur amongst animals under domestication. As for example, friendships between horses and hens. I have known of several such, where a solitary horse in a field will seek out the company of a hen, and the hen responding to, or seeming to respond to the advance, whatever it may be, will separate herself from the other fowls and remain for the greater part of the day, and for many days on end, in the company of the horse. Such associations are common enough, and also between dogs and cats, cats and hens, lambs and dogs, and indeed there are a great variety of such friendships possible between any animals that are not too greatly separated.

Such relationships as these are easily enough observed in the artificial circumstance of domestication. They are, however, rarer in natural environment; but since it is of such common experience that such relations can be readily established in conditions created by men, and since they are also found, though far more rarely, in nature, we are led to the conclusion that the power of instinctive aversion, or indifference between different species, is not so strong as our first wonder at such associations would lead us to suppose.

In another of his books Hudson tells of the strange modifications of instinct which take place in animals of different species which are brought up together in unusual domestic association. He tells of a pet lamb who forsook her mistress to live with a pack of dogs. All the dogs' habits were copied by the lamb. When the dogs lay sleeping in the sun, the lamb would lie amongst them with their heads pillowed on her sides; when they went hunting vizcachas, the lamb went too, and while the dogs dug at the burrows, the lamb frisked from hole to hole, pretending to be as interested as they. Hudson tells also of a cat and rabbit, who because they were brought up together, even went so far in their sympathetic friendship as to copy each other's methods of eating: 'the cat would be seen laboriously gnawing at a cabbage stalk while the rabbit picked a bone.' There are cases too where foxes and fox-hounds have lived together, and the hounds have even hunted the fox, but have never done him any injury, and two instances of otters reared from puppyhood with otter hounds. In one case the otter would go hunting with the hounds; in the second case the otter did not accompany the hounds, or was not allowed to go with them, but the hounds, although they hunted wild otters with all the zeal and fury natural to them, refused to bite or hurt them in any way. Their friendship with an otter had had a psychological effect on their otter-hound natures.

Where Fear is Not

Fear is usually considered to be the most universal, the most fundamental and often the most powerful of all the instincts. For the greater part of their lives most animals are subject to its influence, and the preservation of their existence is effected by constant regard for those dangers of which their fears bring them warning. At the time of mating and in the heat of personal conflict, the males of both birds and animals will become, in their preoccupation with each other, indifferent to dangers which at other times will fill them with alarm, and will so appear fearless. The maternal instinct to protect a young and helpless brood, though not banishing the fears, will overcome them, and the mother hen will run at the dog which threatens her chicks, with great gallantry; and, in the same way, the cows on the pampas of South America will turn on the dreaded pumas to defend their calves. But on neither of these occasions is fear far distant.

In most animals, fear is provoked by the unaccustomed. The domesticated cat which lives on easy terms with a large dog will none the less show every sign of fear when meeting a stranger dog, even though it is a small one. Anything strange, even to man, if its strangeness touch his imagination, is frightening. The swelling of a sponge in a pool of water, has proved sufficient to frighten a whole tribe of Tibetans. Yet there are wild animals in which this sense of fear is only partial, and others in which it is wholly lacking.

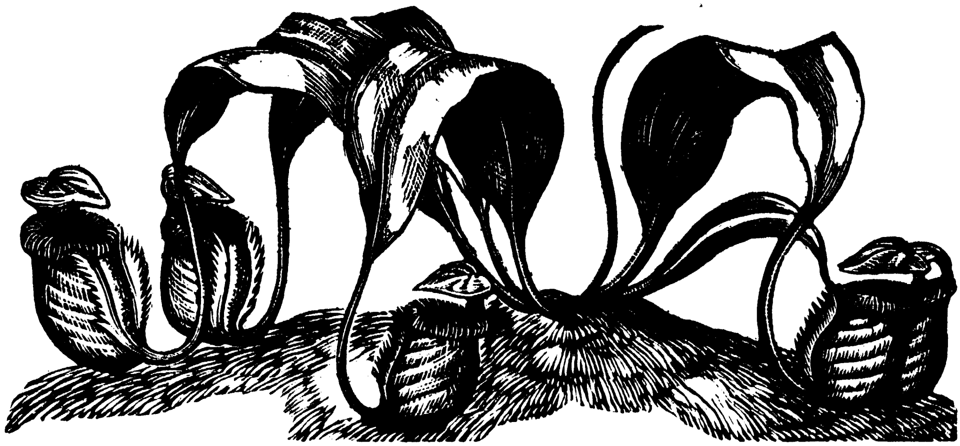
The short-tailed field vole, which is so common in English hay fields, and which in the springtime is so persistent in raiding our gardens for our newly-planted peas, is an animal with a very incomplete sense of fear. I have often caught these little creatures in my hands, and though they make a fairly good attempt at getting away when chased through their native grass-tufts or through newly-cut hay-swathes, once they are caught, they seem part-tamed. Within half a minute of what must, from the vole's point of view have been a violent hunt, the creature is sitting at its ease on the palm of my hand and eating the grains of corn or crumbs of bread that I offer. Its fear has completely gone. Even its desire to escape, which it showed so obviously a few moments ago, could not have been badly fear-stricken, or it could not now eat with such composure. It sits and nibbles and runs a little distance and again sits and nibbles; only when it is in the grass does it show symptoms of wanting to escape.

This absence of fear when in the presence of the unknown and the strange is to be observed in other British animals, but it is not nearly so well marked in this country as in some parts of the world. Charles Darwin in his description of the Galapagos Islands tells how the birds of that archipelago were singularly free from fear, and how slow they were at learning to avoid the dangers that the arrival of human beings have brought amongst them. He tells how that most of the birds of the islands, the mocking-thrushes, the finches, the wrens, tyrant fly-catchers, doves and buzzards, could all be approached and struck down with sticks, and how that with the muzzle of his gun he pushed a hawk off a tree. One day while he was lying resting in the shade, and drinking from a pitcher made from the shell of a small tortoise, a mocking thrush alighted on the edge of the shell which he held in his hand and began sipping at the water. Such examples of tameness were not by any means uncommon, and reports from earlier travellers say that the turtle doves were then so tame (1684) that they would often alight on the heads and arms of the sailors, and could easily be captured alive. At the time of Darwin's visit (1832) they were not quite so tame as this, but appeared to have learnt very slowly that man is a dangerous animal. He records how that a boy on Charles Island, which had then been colonised six years, was able to strike down doves and finches with a switch.

From this tameness of the birds of recently populated archipelagos, he argues that fear is an acquired instinct, and suggests that animals and birds have to learn through long experience who are their enemies, and that mere strangeness is not sufficient to cause fear. In support, he instances the behaviour of other island-dwellers. The birds on the Falkland Islands were as tame as those of Galapagos. Snipe, geese, thrushes and buntings and hawks being easily approached by men, though these all showed fear of the native foxes. They had learnt to fear the foxes but had not yet, at that date, learnt to fear men. Early explorers of other out of the way parts of the world tell the same story of the birds and animals being unafraid. Kerguelen Island which lies midway between Australia and the Cape, when first discovered, had on it many tame birds, and the two native birds of Tristan da Cunha were at first so tame as to be easily caught in the hands.

From this evidence, it would seem that the instinct of fear, which we accept as so universal and so fundamental, is an acquired characteristic. It is not, so it would appear, a thing easily learnt, but needs slowly to enter into the blood and experience of the species. Once it has entered, and the lesson has been learnt, there it remains, and is passed on to the inexperienced offspring. The fledgling sparrow fears men, though no man may have directly threatened it. The young of the wild rabbit is almost untameable. They have behind them generations of persecution. Yet the birds of the Galapagos Islands, though they see their brothers and sisters struck down, are slow to learn of the dangers which threaten.

In the same way, our own most deep-rooted fears have probably come to us through many generations of past experience. Some of these may be temporarily allayed, as are the inherited fears of the domesticated cat for the dog. Because she has been brought up with one particular dog from her first kitten-hood, she does not fear it, but when she sees a strange dog, then her racial experience is remembered in an instinctive reaction of hostility. It is so with us with our own fears and our hostilities; the acquired inheritance of the past is in them revived. But if we follow the argument a little further and accept the evidence of the island-dwelling faunas, then we will believe that our instinct of fear and distrust, which may seem so fundamental, is not part of our original nature, and should not take rank as of the same importance, as our instinct for love or for the protection of our children.



Worlds within Worlds

'Well may we affirm that every part of the world is habitable!' wrote Charles Darwin, and continued: 'Whether lakes of brine, or those subterranean ones hidden beneath volcanic mountains, warm mineral springs, the wide expanse and depth of ocean, the upper regions of the atmosphere and even the surface of perpetual snow—all support organic beings.' Having made this statement, so large in its implications, he allows the reader to contemplate it without further assistance, and turns with a serene simplicity to the continuation of his journal.

Before considering those special instances which Darwin mentions, it is convenient to take a passing glance at conditions prevailing in localities which are in no way peculiar, and which approximate to what we vaguely describe as normal. Those groups of natural forms, both plant and animal that inhabit there, will be seen to have a general inter-relatedness, as for example, the relatedness of common grass to the manureforming bacteria, and to the many forms of animals, insects, birds, mammals, etc., that feed on it. These creatures accept the grass as part of their environment; yet they stray to other foods of other natures, and so are partially dependent on or give assistance to many and various species inhabiting the locality. A general, ill-defined and wide interrelationship is established between the many various groups and species that touch upon each other and sometimes intermingle, and which sometimes appear quite separate within that region where they occur side by side. That we may see more clearly that this is so, we have but to consider such common animals as mice or sparrows and their general relatedness to the world that they inhabit.

Mice, living as they do, largely upon seeds, affect in no small measure the plant population of any district, and their indirect influence is even more potent, for preying on the grubs of humble-bees, they destroy the potential fertilizers of many kinds of flowers. Other insects, either beneficial or injurious, which are eaten by mice, exert their own influence on yet other species, and so further and further, in spreading ripples. Mice themselves provide food for cats, foxes, owls, hawks, snakes and other birds, mammals and reptiles. When mice become unusually common, the species that prey on them will gather from surrounding districts, and for the time the natural equilibrium of the local species will be altered. So it is also with other animals in such 'normal' localities, which support widely interrelated groups.

Yet if we look carefully at any one particular species in these 'normal' areas we will find that it is *directly* concerned

with only a limited number of other species, and that these constitute for all practical purposes its world. A naturalist, in such a contemplation of any particular animal, will inevitably get, should he persevere in his task, an imaginative view of how the world must appear through the eyes and limited intelligence of the creature in question. This view, which by its nature must be largely subjective, must seem at first sight to have little scientific value; yet for the education of the faculties of the observer it will not prove useless, for he will discover that there are worlds within the world, and from the centre of each of such, a definite and peculiar idea looks out upon a universe which it creates, and by which it is conditioned. Where these conditions are specialised or in any way peculiar, these limited worlds, in which most unquestionably the animals do live and have their being, shrink and become clearly defined.

As a first example of such a world within the world consider those lakes where water has evaporated, leaving along their margins crystals of gypsum, and on their surface other crystals of sulphate of soda. The mud beneath the water and the salt crystals is black and with a putrid smell, yet on the surface is a green and red frothy scum. This scum is found to be composed largely of infusoria and confervae, which are able to live in even so strong a salt solution and amidst the forming crystals. These infusoria and confervae form the diet of worms which burrow in the mud, and make possible the presence of these creatures. It is surprising that they can live in brine, yet they do, and so existing, they in turn form the diet of flamingoes which seem not to mind the saltiness of these worms. Darwin recounts that throughout Patagonia, in Northern Chili and at the Galapagos Islands he met these birds wherever there were lakes of brine. The infusoria, living in the mud and finding their sustenance in such organic matter as the droppings of the flamingoes, the worms that feed on the infusoria, and the flamingoes, living on the worms; these form a little living world within itself, and each to the other are directly or indirectly important.

Another example of organisms dependent on each other and isolated in their dependence are the plants and animals which will inhabit a single tree in a tropical forest. Besides the main tree, which supports the lineas and creepers which wind about its stem and hang from its branches, are the numerous plants which grow in the clefts and crevices of its bark; these include orchids, pitcher-plants, climbing arums and Tillandsias, curious hair-like plants which resemble lichens, but which are allied to the pitcher-plants; also numerous ferns, many of them of a creeping habit; and on the ferns and the other plants of the trees, grow many minute creeping mosses and liverworts; parasites upon parasites. Many of these epiphytic plants have devices for collecting water. The pitcher-plants are the most remarkable in this respect, several of them containing in their specially modified rosettes of leaves small ponds, in which various animals and plants live, which are to be found nowhere else. Such various yet peculiar vegetation will support animals of diverse kinds, including snakes, lizards, frogs, birds and a host of insects, spiders, centipedes, etc., all of these living on one tree, and dependent on it for their support, and all of them adapted to that special form of existence. Not only does each tree form a little living world within itself, but each portion of a tree may be regarded as having its own special inhabitants. The tops of the trees where the flowers and the majority of the leaves stretch up towards the light, have their own groups of epiphytes and animal population. Lower levels can also be marked off in horizons, and on the bases of the stems and on the ground live different species of animals and plants. This same phenomena may be observed to be developed in a lesser degree in our pollard trees of Europe. Willows, alders and poplars will support many plants and their attendant animals in the bowls of humus which accumulate at the place where the trees have been lopped. Most of the plants will derive from seeds which are wind-born, and so will show, to a certain extent a natural selectiveness within the group.

The tropical forests throughout the world, no matter on what continent they flourish, present very much the same general features. In all cases the flowers and foliage are thrusting upward into the sunlight at the top of the supporting stems. Little of their luxuriance can be seen from below. In this mass of upper vegetation much of the animal life of the forest is localised. Here live many creatures which seldom or never descend to the ground. Frogs, snakes, lizards, monkeys, squirrels and numerous other species live in the tree-tops, and are specially adapted to that peculiar environment, and it is a remarkable fact that different localities and the species sharing those localities, seem to have hit on different morphological adaptations to meet those conditions. In one district such widely diverse creatures as lizards and squirrels will have both developed a parachute apparatus—a stretched skin membrane between the fore and hind foot to enable them to take wide jumps from branch to branch. This modification will be general in that district. In another district, another device to meet the same ends and the same conditions will have been developed. Long and prehensile tails and arms will here be the dominating feature of the inhabiting species. Regarding such phenomena, one is almost tempted to believe in place daimons, which influence those creatures which live within their orbits, producing in one locality, parachutes and in another prehensile tails. It is certainly a strangc and enigmatic fact, and so far unexplained, that like conditions should produce in one locality one highly specialised development and in another locality another very different though equally highly specialised arrangement of organs, and that this specialisation should be shared by creatures belonging to quite differcnt departments of the animal kingdom.

Other instances of animals sharing characteristics fitting them for their peculiar environment are to be found in all parts of the world. Amongst the most noticeable are desert-dwelling creatures, all adapted to the resistance of drought, and living within the enclosed limits of their environment in a world within itself, in the same manner as the flamingoes and the worms and the infusoria make a complete cycle in relation to the salt lakes. Another such example of adaptation to a rigidly defined environment I have found in the fresh water contained within the neck of an extinct volcano. On the island of Koro, one of the islands of the Fijian group, and entirely volcanic in its structure, there is such a lake containing fresh water. It is reached after a considerable climb up the central core of the island. At about a third of the distance up towards the top of the mountain, one side of the neck of an ancient, now extinct, volcano has fallen away, leaving exposed the open neck in black, basalt rock. From the heights above, water descends in a cascade into the open neck, filling it and overflowing. A pool is formed of about twenty to thirty feet in diameter. The edges of this pool descend perpendicularly. I have bathed in it, and have felt how sheer and steeply they descend. The water is clear and warm on the surface, but a short distance down is very cold. Its depth, according to the natives and the white settlers living on the island, has never been plumbed, though lines have been lowered into it which have reached lower down than the level of the sea which surrounds the islands. Lines with fish-hooks have also been let down, and at a depth of several hundred feet, fish have been caught. These fish as they are pulled upwards in the water blow out their insides and burst, for being adapted to live under the pressure of the deep column of water in the neck above them, they cannot adapt, on their rapid upward journey, to the lesser pressure of the upper layers of water. Their own compensating pressure from within remains the same, and so blows out their insides. Such fish must obviously live, and can only live at a great depth, and in complete darkness. They are fresh-water fish, living in fresh water. Possibly the neck of the volcano, narrow as it is at the surface, may widen out lower down into a large lake. About this we cannot know, but we do know that the fish live in a restricted space of fresh water and at a considerable depth, and we must infer that they find something to live on. That something finds something else to live on, and so, in this restricted underground lake, living under an extreme pressure at a great depth and far from the light of the sun, there exists a cycle of living creatures, a world within a world, even more restricted and confined than that other group which has established their livelihood in the unlikely medium of brine-encrusted lakes.

Some Question Marks

When Æsop wrote, telling stories of animals conversing as though they were men, he pictured common situations and drew obvious conclusions. At the present time with our more exact knowledge of nature, we do not find such simple moral fables, but rather discover, in the lives of animals, peculiar patterns of behaviour; from these emerge vague hints and subtle reflections of human qualities; and although we may wish to look at animals objectively, we cannot, if we look with our whole intelligence, keep our eyes shut to the fact that our own growing perceptions alter the quality and nature of the universe that we regard. We come to see that the subjective view *cannot*, by the very nature of consciousness, be altogether excluded. The patterns that we find in animal behaviour are far more subtle and elusive than any that Æsop devised, and in so far as our objective vision is clearer, so also must our perceiving consciousness become charged with a higher potential of subjective interpretation. This means that we introduce, whether we will or not, human ideals into the contemplation of the animal world, or, to quote Professor Whitehead's words, we can say: 'No biological science has been able to express itself apart from phraseology which is meaningless unless it refers to ideals proper to the organism in question' (*Process and Reality*, page 116). In contradiction to such a view, the mechanistic hypothesis attempts to describe the world as containing existence without valuation, thereby setting up an abstract view of reality as ultimate truth. It takes the world as an independently objectively existing system, and ignores the part played by the perceiving mind. Many biologists and most philosophers have already abandoned this naive realism, and have recognised that what we rather loosely describe 'as the world known to science' is no simple self-existing cosmos, independent of us who perceive it, nor yet a mere subjective creation of our minds, but is an unstable projection of the average psychic life.

Starting from such a viewpoint, which I believe to be the only rational one, we must of necessity find some portion of ourselves in the things which we regard, and so find at least one unifying principle in phenomena. From this objective-subjective view it is only a step to Henrik Steffens' assertion that animals are fixed ideas incarnate. Once the possibility of such an idea is admitted, correspondences of many kinds at once present themselves. The poetic and the imaginative are no longer excluded from the scientific vision, and the human response to the universe will no longer be departmentalised.

Such correspondences have already been hinted at in these essays. The relation between the rabbit and the stoat in which one member of the relationship acts in a way detrimental to itself, and in a way advantageous to its natural enemy, finds its parallel in many human associations, which in contradiction to the beneficial partnerships found between many dissimilar animals, might well be regarded as of disadvantage to one member at least of that relationship. We have but to consider in the light of this idea the many and various human associations with which we are all familiar to see that this is so. Our human trouble is that so many of these disadvantageous associations are not easily recognised as such.

Modern psychology has revealed within that wide range of human associations contained within the family, many varieties of commensalism, parasitism and perhaps most common of all, the sheltering of one life within another, or the exploiting of one life by another, which does not always involve an actual parasitic relation. It is almost as though human psychological associations had been copied from some of the more bizarre partnerships that obscurely occur amongst lower animals. This resemblance may perhaps more correctly be expressed by saying that the same pattern is revealed in the one, in psychological terms, in the other, in physical.

There is a small fish called *Fierasfer* which inhabits waters where sea-cucumbers or Holothurians abound. Holothurians are degenerate animals which lie prone and motionless on submerged rocks, frequently on coral reefs. They are also found in deeper waters, and they live by taking sea water into their bodies, obtaining from it what nourishment they need, and expelling it again. Consequently they have within their bodies large water-spaces. The *Fierasfer* is a slender little fish of from four to seven inches long. Its body is nearly transparent and is only slightly pigmented. It tapers from head to tail and has dorsal and ventral fins extending the whole length of its body. In nature it is found lurking inside the water-spaces in Holothurians, and is only found in those specimens taken from deep water. Those in shallow water are free from these uninvited guests.

In aquariums the associations of these fishes with Holothurians has been carefully observed. With their noses the fish seek for the anal vents of the Holothurians. These openings are constantly being expanded and shut to allow for the flow of water from the respiratory cavities. Having found the opening, the fish bends its flexible body and inserts its tail. It then backs its way up into the Holothurian, and there, in the protected safety of the water-cavity lives a great part of its time. It is not strictly parasitic on its host. It makes excursions to find its own food, and returns to its resting place. Several of these little fish will associate together within one host. They are uninvited guests, who exact lodging but no board.

Another fish, which is an uninvited guest, but of a different nature, is the *Remora*. This is provided with a sucking disk on the back, by which it can attach itself to larger fish such as sharks or to whales, porpoises and turtles. These do not feed on their hosts, but in all probability pick up scraps that their larger hosts let drop. The sucking disk is a modification of the dorsal fin, and it is a very efficient organ. On the east coast of Africa, the natives use the *Remora* for catching turtles. They fasten a metal ring round the base of the tail, take the *Remora* with them in a boat and when a turtle is sighted, throw the fish in the direction of the turtle. Its habit is to fasten on to something, and so it fastens on to the nearest object, namely the turtle. So strong is the sucker that the natives can pull the turtle thus captured to the boat.

Other creatures of a quite different nature, but which evoke questions difficult to answer are the various insects which infest the dead mulga bushes in the Australian bush. On the living bushes are to be found the usual population of caterpillars, beetles, stick-insects, cockroaches, etc., but the dead bushes would seem to attract each its own particular form of animal life. Some of these dead mulga bushes I have found to be covered, literally covered with hundreds of ticks, and this, when there were no other ticks visible in the neighbourhood. The ticks hang on the dead branches by two of their eight legs. The other legs are stretched out, in the hope, usually a vain hope, that some blood-possessing creature may pass by. At the least touch the ticks loosen their hold, and once in contact with living flesh attempt to suck blood. As they hung on the trees they were flat and utterly emaciated, only their legs showed any sign of life. On the dead bushes they hung until they died, and after their death they would still cling there, hundreds of starved corpses on a withered bush. Why they should be there congregated in so unpromising a place I could never imagine.

Sometimes it would be a host of mosquitoes that took possession of a dead bush; there they would sit like a black fur upon the branches. Sometimes butterflies would gather on other dead mulga, the brilliant metallic, blue-winged butterflies of north-western Australia, or the dark hairstreak butterflies. These insects would also flutter around living bushes, but never in such numbers as round a dead bush, and there too in their hundreds they would sleep in the evenings. It may be objected that the ticks, the mosquitoes and the butterflies were on the live bushes too, but not so easily seen. It may be there were a few, but the large gatherings were always on the dead bushes, for which they seemed to have a particular attraction. There was no doubt that they preferred the dead bushes, and in the case of the ticks, they lived and died there without a morsel of food.

Outside the range of recorded facts and checked observations, there lies a large land of folk-law concerning animals and their relations to men. A great many of such folk-lore stories are obviously false, but there are others, which, incredible as they may seem at the first sight, may have some elements of truth in them, or may be indeed true. I will give but one instance of such a folk story, and will add to it the experience of a modern practising psychologist. The experience does not indeed confirm the truth of the tale, but it may, in the view of some readers at any rate, give it a significance, and leave them with an open mind with regard to so obscure a subject.

There is a tradition in Scandinavian countries that magpies are badly affected towards certain individuals. There are believed to be people who are under a kind of spell in relation to these birds. This spell may be inherent and suddenly make itself manifest, or it may be deliberately put upon one individual by another. People suffering under this spell are attacked by magpies on all occasions on which they show themselves in the open, and they consequently suffer from an extreme fear and horror of these birds. There are stories of women who have lived for years inside their houses, behind drawn blinds rather than risk any sight or contact with these ill omens.

Such a story as this may well be considered a mere fairy tale, and what place has it in a book which purports to deal with facts? What follows is, however, a recorded fact, and those psychologists who have had but occasional glimpses into the obscure places of the human soul will not find it so very surprising. A well-known psychologist was treating a patient who was suffering from an extreme phobia of birds. This woman complained that she was constantly attacked by birds, and in particular by blackbirds. The doctor having heard all her story and fully realising the reality of her fear, gently suggested to her that these birds that she maintained attacked her might in reality be subjective hallucinations. The woman was intelligent enough to realise that this indeed might be so, although her own belief was strong that the birds were actual birds which flew at her out of the hedges.

During the summer when the weather was fine, the doctor would sometimes receive his patients in a summer-house in his garden. On the first occasion that he took this particular patient to the summer-house, they were walking side by side, when a blackbird flew screaming at the woman and fastened with its claws on her blouse. She screamed and fainted. The doctor brushed aside the blackbird and supported the unconscious woman to the summer-house. As soon as she regained consciousness, she asked: 'Was that a real one, or a subjective illusion?' The doctor was forced to admit that in this case it was real. Here was indeed an animal metaphor fluttering out of the realm of symbols into the actual.

If, with Henrik Steffens, we ever come to regard animals as fixed ideas incarnate, then such associations of symbiosis as are instanced by the relation between medusae and fish or between polyp and crustaceans, as described in the earlier volume of *Enigmas*; such relationships will not then seem quite so mysterious and unrelated. Commensal partnerships, and such odd associations as that between the *Fierasfer* and Holothurians, even the behaviour of blood-sucking ticks, dying in their hundreds of starvation on long defunct mulga bushes, and even also such antibiotic affinities as those of the rabbit and the stoat and the lady and the blackbird; these will then not appear to us merely as the odd hazards of chance, but rather as intimations of things, which for their greater part escape our sensual experience, but which to an increasing consciousness may yield their secrets.

Death in Nature

Seldom in fields or woods do we see the dead bodies of animals. Occasionally we come on the skeleton of a rabbit and sometimes the shrivelled remains of a shrew or mole. It is unusual to find the body of a dead bird, yet living birds are always around us in their hundreds in the trees and in the air. This same rare occurrence of the dead bodies of birds or animals is usual in most other parts of the world. In the Australian bush, in the jungles of South Sea Islands, in the desert or in the forest, there are usually living creatures to be seen, but few dead ones. What happens to all the dead bodies?

The obvious answer is that the great majority of birds and beasts are preyed upon by other creatures which devour their dead bodies. No doubt a great number are disposed of in this way, but not so many as we are at first inclined to think. Accidents can happen to animals and birds as to men, and adverse conditions of climate can account for many deaths. On cold mornings after exceptionally hard frosts, I have seen rooks hanging, swinging from their perches head downwards, quite dead, frozen during the night, with their claws still clasped about the twigs they perched on. Owls and jays I have also found in this condition, but not often. In the exceptionally cold spring of 1916 it was a common sight to see blackbirds and thrushes dead or dying by the wayside. In cold weather a great many small birds such as tits and wrens die; but though winter and bad weather may take a heavy toll, and though the great effort demanded by migration may account for many more lost lives, are these causes of death, together with the depredations of predaceous species, sufficient to account for all the deaths that each year must occur? Are there not also what are usually called natural deaths?

Gilbert White describes how he has seen rooks fall suddenly dead in mid flight, and most people, who keep their eyes open and who know the country well, will at one time or another have chanced upon creatures which were at that very moment in the act of death: birds that swayed trembling on a twig, and that lay dead in the hand that lifted them, or a mouse or a rabbit that shuddered and stretched itself and died. These are but rare occasions, and would seem exceptions to the rule, that dead or dying animals are seldom met with in nature. One reason for this scarcity of dead creatures which must not be overlooked is the fact that their small bodies very soon decompose or are devoured by ants or by the larvae of flies or of beetles. Burying beetles must account for quite a number during the summer months, for these *necrophli* are marvellously far-scented and will discern from a distance the faintest odour of decomposition.

Most animals when injured or suffering from shock, will creep apart into some private place and hide themselves. If their injury should be mortal they will die while thus safely hidden from observation, and their dead bodies are not likely to be found. This may very well be the rule that the death-stricken animal hides itself and dies in isolation, but to this rule, if it is the rule, there are interesting exceptions. W. H. Hudson tells how the huanco or small wild camel of South America have, in southern Patagonia, certain localities to which they retire when they are about to die. These localities are withdrawn from their usual feeding grounds. 'The best known of these dying or burial places', he writes, 'are on the banks of the Santa Cruz and Gallegos rivers, where the river-valleys are covered with dense primeval thickets of bushes and trees of stunted growth; there the ground is covered with the bones of countless dead generations.' Charles Darwin, also writing about the huancos says that in most cases they must have crawled, before dying, beneath and amongst the bushes. The exceptional thing about the huancos is, not that they should retire in solitude to die, for this is a usual practice, but that a large number of individuals of the species should retire to the same place. In his *Naturalist in La Plata* Hudson gives several ingenious explanations for this unusual behaviour, and is much concerned to turn its apparent uselessness to a one-time though lost usefulness, or at any rate to provide a hypothetical origin for the instinct, which in some past time, may have served as an advantage. Before accepting such ingenious explanations too readily, it is well to remember the case of the lemmings, which at certain times and seasons throw themselves into the sea and perish in vast numbers. Again, it is suggested that they are trying to migrate. Yes, but most creatures, when migrating, migrate to regions of safety, and not into the region of death.

But to return to the huanco; perhaps these animals are not unique in their death migration, though Hudson suggests that they are. There are travellers in Africa who record the accumulations of large stores of elephant ivory. These rich stores of ivory may have been collected in past times by men and buried in the jungle, or they may record the dying places of long departed elephants. The facts about these reputed stores of ivory have not so far as I can learn been checked, but there is no doubt about the tradition that elephants also have such dying places.

Another fragment of evidence which may point to some such similar habit is supplied by the gazelles inhabiting some of the islands of the Red Sea. These small gazelles appear also to have their special dying places, to which they retire when they feel the promptings of death, and there their bones and horned skulls accumulate, marking these special localities where many past generations have died. On islands in Shark's Bay, West Australia, various small rodents which live for the most part in open runs, tunnelled under projecting low cliffs, have special places where their bones are found in large numbers. These mice and rats which live most of their time in short burrows or caves only venture out at night when they go down to the pools, left by the tide, to drink the salt water. In certain of these small caves or even in recesses by the sides of the runs, I have found large numbers of bones; these were not gnawed or broken, but lay one upon another, as though left there at different times, layer upon layer, and had gradually sunk into the earth, by reason of the shifting dust, and the passage of the feet of the living mice as they ran along the well-worn tracks. I have been puzzled as to how these collections of bones could have been made and for what purpose. Is it possible that the mice, like the huanco and the gazelles, have their specially favoured localities in which to die? On these islands the small rodents have few enemies who would devour them. There are no cats and weasels to hunt them to their holes. Their numbers are probably kept in check by the hardness of the climatic conditions, such as the absence of fresh water, yet of those which do grow to maturity, a large number may live and die natural deaths. These individuals, it seems possible, may seek their own dying places. What purpose such localities may serve I am not bold enough to suggest. Theories as to possible usefulness or otherwise, may in time be propounded when the subject has been further investigated, but for the present is it not reasonable to believe that, as in life animals are guided by instincts which take on definite tropisms which turn them seasonally from one habit of life to another, so also creatures touched by the instinct for death, can turn aside as automatically towards localities which are harmonious to their mood.

Immortality and Death

Biology is by definition the study of life. Orthodox science finds in life a process of metabolism, a psycho-chemical change from one condition to another, and with this change growth and decay. The protoplasm of the cells changes, giving off waste products, the nuclei divide, the cytoplasms increase and new cells are born, tissues enlarge within the limitations of the formal pattern, and so, we say, the creature grows and lives. Its organs breathe, digest, excrete, store energy and expend it; these processes happen for a time, then cease in death. Science does not yet admit life, or, in particular, qualities of consciousness and memory, persisting beyond death. Of these attributes of life, science can find authentically recorded evidence only between birth and death; what happens before and after is unknown.

The enigma of the void beyond, towards which all life tends, is perhaps the largest of all our human enigmas, and the one on which most thought and fancy have been expended. Science, which can find nothing to record beyond those changes of decomposition which take place in the body at death, stops short there. It scrutinises and experiments, with the bodies of creatures as they are found existing in life; it has determined our picture of the living organism, built up of a number of cells, and one of its most striking conclusions is that it finds, within the limits of the physical body, conditions not only of mortality, but of immortality.

Animal and plant-forms grow from small, unicellular beginnings, they increase in size, attain maturity, grow old and die, yet in each individual there is contained a potential immortality.

To consider the simplest creatures first. Among the noncellular or unicellular animals and plants this immortality is most obvious. These reproduce themselves by a process of simple division. They divide into two parts, each part taking a portion of the original substance to make a new, smaller individual. These in turn grow larger and again divide, and in this way, what was one, becomes many; the original living substance spreads itself and does not perish, except through such accidental causes as being eaten or destroyed by some other living creature, or by finding itself in some uncongenial surroundings. There is no natural, unaccidental death in these primitive forms of life.

Paramecium, a ciliated infusorian, a unicellular animal of comparative simple physical structure, having a cell-wall covered with fine hair-like processes called cilia, a mouth, an

anus, macronucleus, micronucleus and contractile vacuole, has, for many generations, been kept under observation. L. L. Woodruff has demonstrated that this little animal is able to continue reproducing from generation to generation without experiencing natural death, and is therefore potentially immortal; he has shown that the original substance of an individual, though it divides and divides again and again, does not necessarily perish, but continues to live. Death, though it may be accidental, is not an inevitable portion of its fate. Woodruff observed *Paramecium* for more than eight thousand five hundred generations, during which time (thirteen and a half years) there was no conjugation. During this time the individuals which resulted from these repeated divisions remained perfectly healthy. Such a series of generations, if translated into human terms, would represent some million years. During this time there was no occurrence of natural death, for each individual when it came to the end of its single existence, divided into two; these grew for a while as single units, until in their turn they again each divided.

Not only with *Paramecium*, but with other species, have similar results been obtained, and the conclusion is firmly established that for unicellular organisms there is no natural death, except in such exceptional instances as the lactic acid bacteria, which produces as the result of its metabolism an acid, which, when it reaches a certain percentage of the milk in which the bacteria live, will kill all the bacteria which have produced this excretion. In this case death may be said to be natural and inevitable, for should the bacteria find conditions sufficiently favourable for their growth and reproduction, they will then produce the acid which, in time, will prove to themselves a poison. But this case is exceptional.

Reproduction by simple division is not confined to unicellular organisms; there are a few of the simplest and most lowly organised animals in the *Metazoa* which have this power of multiplication by fission. Planarian worms will bud off portions of themselves and thus divide into two; in this way, though the original substance is divided and diluted with each division, it cannot be said to perish or die. Such reproduction is called agamic, and though comparatively rare amongst multicellular animals, is common amongst plants. The apple, plum and pear trees in our orchards are all examples of agamic reproduction, though in these cases the trees perish, and only that part which is removed as a graft survives. They have been grafted as buds on to stocks; the buds have been taken from trees which may well by this time be dead, and certainly will die, but they themselves are alive, and should buds be taken from them and grafted on young stocks, they will live long after the parent trees are dead. The living substance conveyed in the bud does not necessarily perish. Here it should be noted that the stocks are not essential to the growth of the bud, only practically convenient, The cutting will grow its own roots, if sufficient care is taken.

Only in the higher multicellular animals does death appear to be the natural consequence of life. So it would appear! Yet the investigations of science suggest that death from 'natural causes' is the result of conditions which are very obscure, and that the deaths of individuals are not caused by any predisposition of the essential constitution of their parts. We know that all the animals which are most commonly observed have their allotted span of hours, days or years, yet when we come to look closely at their constituent tissues, we find that within them, and throughout them, there lies concealed an immortality.

In the higher animals, the new individual is not produced by division, but by the union of two peculiar cells of extraordinary potentialities, called germ cells. These germ cells are of two sorts, ova and spermatozoa. In bisexual organisms the former are born by the female, the latter by the male. Both sorts undergo a complicated preparation for the union which is to form the fertilised cell or *zygote*, from which the future individual is to develop. In the developing individual the zygote divides many times, forming increasingly complicated groups of cells which constitute the organs. At an early stage in this development, those cells from which the germ-cells of the new individual are to arise, are set aside in a definite position in the growing embryo; these remain localised and recognisable. These germ-cells of the second generation give rise to the third generation, and in these individuals also the germ-cells of the next generation are early set apart.

The cells which give rise to reproductive cells have a quite different fate from those cells which give rise to other organs. These latter die with the individual when that period which is the natural span of its life is accomplished. So also do those germ-cells which happen to be contained within the body at that time, but these latter die by accident, and those of their number which have already united with other germ-cells will have developed into new individuals, and have produced new germ-cells, destined to create yet other individuals.

To sum up this proceeding, we may say that the united germ-cells produce a body, and within that body other germ-cells. The body dies, yet some of the germ-cells have produced other bodies and other germ-cells, and so on in a continuous succession, which has never ended. The line of life is unbroken, and the substance which carries life carries within it a potential immortality.

The discontinuity of existence does not appertain to life itself, but only to the bodies of one class of living things, namely to multicellular animals and plants. Natural death would seem, in the light of these investigations, to be an experience which has appeared late in the evolution (or the creation?) of organic forms. Death, we see, is no *necessary* tribute or inevitable consequence of life. Life can and does survive all the time untouched by death; and we may say that the death which claims the bodies of the higher organisms is the price they pay for the privilege of enjoying specialisations of structure and function. The main business of living has continued from the beginning until now, untouched by death.

But not only are the germ-cells found to be potentially immortal. A series of experiments have been made which prove that the tissues of the bodies of the higher animals are, in special conditions, also endowed with immortality, although in the natural course of events these bodies, if left entire and functioning in the normal way, will die. If portions of them be separated from the individual and kept in appropriate conditions, these portions will continue living indefinitely. M. T. Burrows, R. G. Harrison and Leo Loeb have all demonstrated that the life in the tissues and organs can be kept going indefinitely. Burrows has succeeded in cultivating cells of the nervous system, of the heart and of the muscle tissue of a chick embryo, which cells showed every sign of continuous growth outside the body. He has demonstrated that the isolated heart-muscle-cells of a chick embryo can grow and beat rhythmically in a culture medium.

Dr. A. Carrel has found that cells taken from most of the organs of dogs, cats, chickens, rats and guinea-pigs and men can be cultivated in suitable mediums outside the bodies of their original possessors; and he has kept cultures of the chick embryo alive for a long period of years, at the normal temperature of the chicken's body, thus demonstrating that the life of detached cells in the artificially-tended culture was longer than that of the ordinary hen. These remarkable experiments demonstrate the probability of the potential immortality of the body cells, since they show that body-cells have lived outside the body for a longer time than the normal duration of life of the species. They show that a potential longevity is inherent in most of the different kinds of the cells of the body. To bring this potential longevity into actuality, special and appropriate conditions are necessary.

What then is that influence which brings about death in normal conditions? Various theories have been advanced. Weissman in 1881 propounded the thesis that death was an adaptation advantageous to the race, and had arisen and was preserved by natural selection. At that period the theory of natural selection was being worked very hard, but at the present day there are few biologists who would carry it as far as this. Metchnikoff maintained that death was the result of autointoxication resulting from the absorption of poisons from the alimentary canal. This theory no longer has the strength that it once appeared to have, since metazoan organisms have been made to live completely aseptic lives, and death has still occurred at the usual time. Johannes Muller said that death was inherent and innate, and to this statement we find a parallel in Freud's death instinct. H. M. Benedict, working on the senility of plants has reached the conclusion: 'that the duration of life is directly linked with the degree of permeability in that part of the living cell which places it in contact with the universe about it, and that, as the activities of life proceed, the cell is being gradually entombed by an inevitable decrease in the permeability of its protoplasm.'

'While decreasing permeability furnishes a possible explanation of the more obvious symptoms of senility, it cannot be the only factor of degeneration of first rank. All protoplasmic functions must be involved. Underlying these primary causes of senile degeneration, there must be some general fundamental cause from which they spring. The fundamental cause may well be the colloidal nature of protoplasm.'

This statement, not at variance with the conclusions of Pearl and Loeb, carries some interesting implications. Raymond Pearl sees in the differentiation of the organism the cause of death, and this opinion is supported by those facts which show that groups of cells from any of the essential tissues will live indefinitely if isolated in suitable cultures. The fact of differentiation results in a need for harmony between the different parts, and should this harmony be interrupted, then one set of organs will be weakened in relation to the others, and will break down before the rest. This actually happens, and as the disharmony increases, it gives rise to illness and death in the organism. In close agreement with this, Loeb writes: 'Death is not inherent in the individual cell, but is only the fate of the complicated organisms in which different types of cells or tissues are dependent upon each other. It seems to happen that one or certain types of cells produce a substance or substances which gradually become harmful to a vital organ . . . or that certain tissues consume or destroy substances that are needed for the life of some or certain organs.'

A concise statement, and yet how gloriously vague! And in the reading of it, one wonders why biological science should have such assurance when supposing *substances*, and should be so shy of supposing invisible influences, which may well be inherent in life, which is itself invisible, and which may control death? Such questionings lead to the larger question: Is it really open-minded and truly scientific, in the larger meaning of the word, to insist on regarding life as a purely mechanical phenomenon, regulated by chance, and without any noumenon significance?

Before turning to the consideration of these questions, I will quote a passage from H. S. Jennings, an American biologist writing on the subject of Life and Death in Unicellular Organisms. This quotation, without answering such questions, will give to them, I believe, an increased significance.

'As individuals the infusoria do not die save by accident. Those which we now see under our microscopes have been living ever since the beginnings of life; they come from divisions of previously existing individuals. But in just the same sense, it is true of ourselves that everyone that is alive now has been alive since the beginning of life. This truth applies at least to our bodies which are alive now; every cell of our bodies is a piece of one or more cells that existed earlier, and thus our entire body can be traced in an unbroken chain as far back into time as life goes. The difference is that in man and other higher organisms there have been left all along the way great masses of cells that did not continue to live. These masses that wore out and died are what we call the bodies of the persons of the earlier generations; but our own bodies are not descended by cell division from these; they are the continuations of cells that have kept on living and multiplying from the earliest times, just as have the existing infusoria.'

In this manner a biologist regards the unbroken continuity of life and the eternal nature of life, seeing death as an almost accidental happening, yet as an *universally* accidental happening arising from differèntiation, an accomplishment of that specialisation achieved by the eternal life. This conclusion is confirmed and elaborated by other writers. Raymond Pearl writes: 'We may fairly say, I believe, that the potential immortality of all essential cellular elements of the body either had been fully demonstrated, or else has been carried far enough to make the probability very great that properly conducted experiments would demonstrate the continuance of the life of these cells in culture to any definite extent. . . . What I am leading to is the broad generalisation, perhaps not completely demonstrated yet, but, having regard to Leo Loeb's work, so near it as to make little risk inhere in predicting the final outcome, *that all the essential tissues of the metazoan body are potentially immortal.*' And further, '*It is the differentiation and specialisation of function of mutually dependent aggregate of cells and tissue which constitute the metazoan body which brings about death, and no inherent or inevitable mortal process in the individual cells themselves.*'

Such then is the conclusion when we regard death and immortality with a purely objective eye. Life is seen to be continuous and unbroken from the beginning until even now. The forms of life change and pass, and as these forms reach a certain standard of elaboration, they die, although the life which inspired them continues.

If now we change the angle of our scrutiny and instead of regarding the expressions of life in other organisms, look within ourselves at our own consciousness, we find, if not the value of our life, at least its immediate reflection; and what we here discover is memory. Memory is itself a complex of thoughts and feelings of past and present; and these, together with our thoughts and feelings about the future, make up that larger complex which we call soul. The soul, or body of desire, as it has been called, is comparable to our physical body in that it is something formed by life (though not necessarily in the direct line of its primal continuity). This soul or memory-complex has a structure, as has the body, and is as specific. It is related to the body, in that the experiences of the one are often the experiences of the other, indeed all the body's experiences must have entered at one time into the experiences of the soul. Even the unconscious experiences of the body have entered into the composition of the soul. The two are inter-related, and, whether the soul has any separate immortality or any continuance of life after death, we know that between birth and death the soul and the body are closely associated. Not only in man is this complex of memory, thought and desire; we can observe in the behaviour of animals the same kind of unifying and governing factor. If then there is this complex, both in man and the higher animals, is it not reasonable to assume that as the body and its experience influences the soul, so too shall the soul influence the body?

Psychologists and philosophers have propounded many answers to this assumption, but these have no place in an essay which attempts only to review the experiments which have been made on the living tissue and which determine whether that tissue is potentially immortal, or whether within itself it carries the seed of death.