II

THE BIOLOGICAL FOUNDATIONS OF INDIVIDUALITY

The idea of individuality, in common with most other large biological problems, came to be first considered—as indeed was only natural—from the standpoint of man alone. With the growth of our knowledge concerning invertebrate animals, the ideas thus gained had to be considerably modified, until finally the theory of evolution once and for all justified the more advanced among the earlier thinkers, and showed that in any view of animal individuality as a whole, we must not take man and mammals as the single starting-point whence we could logically work backwards to all the rest of the organic world, but must regard them as an ending instead of a beginning, and, what is more, as but one ending among many. From the single beginning, many lines have branched out to the many endings, and the only logical method is to start from the beginning (where, too, the phenomena themselves are far less complicated) and trace out each line to its ending, instead of trying to bring the various endings into relation with each other. Each ending is only intelligible through its history, and the history of one is different from the history of another.

The one advantage possessed by the anthropomorphic view of individuality (which, as a half-unconscious product of every-day experience, is still held by the great majority of those who are not professed biologists) lies in its dealing with long-familiar things. Since, however, this is a very real advantage to those who are approaching a subject the major part of which is bound to be not at all familiar, "full of strange oaths," and so bristling with new names that "bearded like the pard" is scarce a stretch of metaphor, we shall begin here with man; thence, taking stock of the more obvious facts of comparative anatomy, with the historical or evolutionary idea to aid us, try to extend the conception from man to the rest of the animal kingdom; then we shall have to show some of the chief difficulties which attend upon this point of view; and finally, having thus cleared the decks for action, we shall be able to take up our subject anew from its historical and logical beginnings.

A normal adult man or woman is an organism, whose complicated and varied parts are almost all designed for one end—to prolong the existence of the whole to which they belong.[1] It is in fact a machine which has the power of running itself, independent, within wide limits, of what is happening in the rest of the world. Unlike our artificial machines, however, whose working is constant, and whose only change is one of wearing-down, the running of the organic machine leads to changes in the actual structure of the machine, and so to changes in its working. We develop of necessity, of necessity we age, and at the last we die. But we remain the same individual throughout—on that all common use is agreed. Till death, when we obviously cease to be whatever we have been before, we preserve our individuality in spite of all fundamental differences in appearance and behaviour. But as to our nature before birth, there the common view is at a loss; its uncertainty has found expression in Milton's words, when to Limbo he consigns, not "Eremites and Friars" only, exiled thither for theological reasons, but "Embryos and Idiots" as well.

The very conjunction of his words will help us out of the difficulty. In our thought, the idea of human individuality has become interwoven with that of personality—a purely mental attribute. Even though by *embryo* Milton meant *abortion*, the lack of mentality—of personality and of soul, if you will, which it shares with the idiot, is the same whether it be within or without the womb, and he was right in regarding its fate as a grave theological problem. But (though the reasons for the defect of mental power are different in the two cases) an embryo cannot because it lacks personality be considered to lack individuality too, any more than an adult idiot can, although the individuality is no doubt less intense or perfect than in the normal adult man. It is this confusion of personality and individuality that raises most doubts in the mind of the average man as to the claims of the foetus to be called an individual. The other chief doubt arises from its incapacity to live out of its mother's body. But reflection will show that the embryo is like every other living thing in being able to exist only under certain defined conditions, which are merely much narrower for it than for the adult man and the generality of animals. (See pp. 100–101.)

Thus we can take the individuality of man back before birth to a stage when the embryo ceases to be easily recognized by the naked eye. To trace it still further, the man of science with his microscope and his knowledge of simpler animals must step in. There the ordinary man must pause, and there we will leave the question for the present; turning now to see how far his anthropocentric notions of individuality radiate out to other living things.

We find that he unquestioningly applies the word to all the familiar creatures of everyday acquaintance, the four-legged beasts and the birds, the snakes and the fishes. This is his unconscious Comparative Anatomy—he recognizes instinctively the community of general plan he shares with them. This unconscious reasoning will carry him still further: he will not hesitate when it comes to snails or insects or worms—in fact, show him anything with a mouth and a stomach and he will dub it an individual. So far, all seems plain sailing.

In reality, this is exactly where all the difficulties begin: without studying the outward form and minute structure of himself and of other animals at all stages of development—without some knowledge, that is to say, of all the numerous branches of the science of Zoology,—it is impossible for him to extend his knowledge of individuality any further, and when he does call Zoology to his aid, he finds that in every direction it seems to lead to contradictions, raising difficulties worse than those it lays. To start with, he has been considering till now only those of the lower animals which slip naturally into a scheme taken from the pattern of Man. A mustering of all the clans soon reveals numerous types of animals that will not fit this frame at all.

There are communities, such as those of bees and ants, where, though no continuity of substance exists between the members, yet all work for the whole and not for themselves, and each is doomed to death if separated from the society of the rest.

There are colonies, such as those of corals or of Hydroid polyps, where a number of animals, each of which by itself would unhesitatingly be called an individual, are found to be organically connected, so that the living substance of one is continuous with that of all the rest. Sometimes these apparent individuals differ among themselves and their energies are directed not to their own particular needs, but to the good of the colony as a whole. Which is the individual now?

Histology then takes up the tale, and shows that the majority of animals, including man, our primal type of individuality, are built up of a number of units, the so-called *cells*. Some of these have considerable independence, and it soon is forced upon us that they stand in much the same general relation to the whole man as do the individuals of a colony of coral polyps, or better of Siphonophora (pp. 89, 91), to the whole colony. This conclusion becomes strengthened when we find that there exist a great number of free-living animals, the Protozoa, including all the simplest forms known, which correspond in all essentials, save their separate and independent existence, with the units building up the body of man: both, in fact, are cells, but while the one seems to have an obvious individuality, what are we to say of the other?

So far we have treated the problem statically, as it were: when we come to view it dynamically, tracing the movement of life along its course, the difficulties do but increase. Take, to begin with, a simple colony of Hydroid polyps (Fig. 2), and ask how does this multiplicity of connected animals arise? Observation shows the whole stock to be formed, by a process of budding, from one original individual. A little lump or knob is seen at one place, which, growing rapidly, bit by bit assumes the appearance of the individual whence it has sprung; it takes its origin in a small group of cells (not in a single one) and its growth depends on continued growth of the substance of these cells, accompanied by their repeated division. By this means, the first individual produces a second out of itself. Its own individuality is not lost in the process; it is, however, impaired, for though the creature's organization is practically the same as it was before, yet it is no longer separate in space, and that part of it below the bud's point of origin is now the common property of the two individuals.

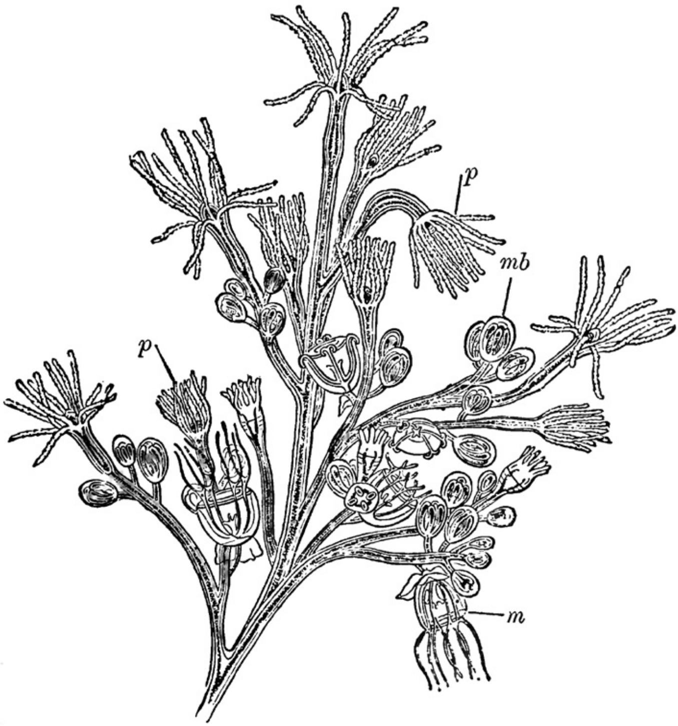

Figure 2
Portion of colony of *Bougainvillea fruticosa*, magnified. *p*, polyps; *m*, medusae; *mb*, medusa-buds. (From Lubbock, after Allman.)

The second individual and the remaining members of the colony, which are all formed in the same way, differ from their original only as regards their mode of development and, as a consequence of this, in never having enjoyed a free and full individuality. The relation of the individuals in a colony to each other is thus rendered still more obscure owing to the fact of one being produced out of another. What was at first nothing but a part grows up into a new whole.

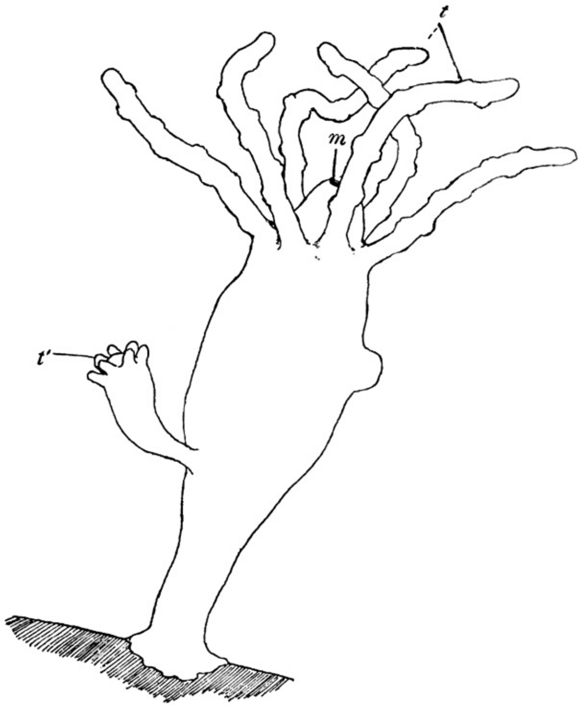

Figure 3
Hydra, semi-diagrammatic, showing a bud-rudiment on the right and an advanced bud on the left. *m*, mouth; *t*, tentacles; *t′*, tentacles of bud. (Magnified.)

Budding, though perhaps most striking when it leads to the formation of a colony, is by no means restricted to colonial forms: often, as in Hydra (Fig. 3), the process is completed, and the bud set free to lead an independent life. Here one individual has produced a second out of its own substance: the two resemble each other not less closely than two individuals bred from the egg, and yet the first has lost not a jot of its own individuality in thus creating itself anew in the second.

This fresh creation of new forms from the substance of the old is what we usually term Reproduction. Budding is but one of its many methods, and we must look at some others before we can see its full bearing upon our subject. First we will take fission, or division into two halves, a method which occurs in several groups of the higher animals, though less commonly than budding. Rarely, as among the stony corals, are colonies produced through its means; usually the two halves part company and each becomes as perfect an individual as its parent. It is, however, in this relation of parent to offspring that division is at variance with budding. Instead of one individual producing another, here the founder of the race ceases to exist, losing his own individuality in the production of two fresh ones. A glance at Fig. 4 will show that the whole substance and the whole organization of the first individual is separated in division into two discrete masses, each of which is incomplete in possessing only half the normal structure. These incomplete individuals, in the examples we have chosen, and in many other animals as well, do not as one might expect complete themselves by keeping the old half-organization intact and budding out what is missing, but, by a method involving a more radical destruction of the parent's individuality, they remodel their structure by a strange internal mason's-work, turning the materials that but now constituted a half-individual into a whole. From their parent they receive the half of its substance and the half of its organization; they make a new organization without adding to the substance.[2] Growth subsequently increases their size without altering their individuality or organization, until, on attaining to the prescribed limit, they repeat the process. Division is thus even more important for the present purpose than budding; we have the strange paradox that though each individual

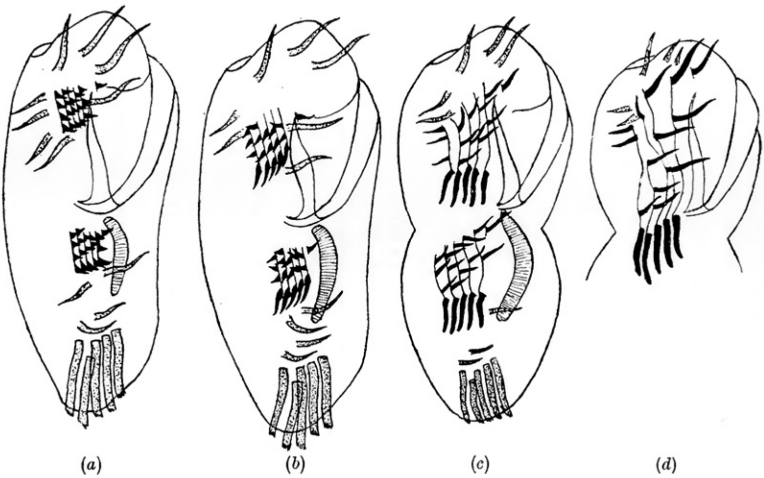

Figure 4
Four successive stages in the division of *Stylonychia mytilus*, a Hypotrichous Ciliate Protozoan, from the ventral surface. (Highly magnified.) The outlines of the mouth and the 17 ventral *cirrhi* (locomoting bristles) are shown. Just before division there appear 17 small processes (drawn black) arranged close together in six parallel rows. These enlarge, spread over the body, and become the cirrhi of the daughter-cells, while the parent's cirrhi (stippled) become displaced and at last completely absorbed. The new mouth-region is shaded transversely. In (*d*), division is not complete, but only one half is drawn. (After Wallengren.)

hands on the whole of its substance intact to its successors yet with this perfect continuity of substance there co-exists perfect discontinuity of individualities.

There remains the third chief mode of reproduction. In considering the hydroid colony, we found that all its members took their origin, by budding, from one single founder. This founder, though identical in organization with the rest, has yet not had the same origin as they. Tracing its life backward towards its source, we find it first of smaller size; then comes the stage when its organs are developed one by one, much as in the bud; before this it exists in a form through which the budded individuals never pass—as a small drawn-out ovoid, actively swimming instead of fixed to the ground; before this again it is seen as a round motionless body, built up like a mulberry out of rounded parts, and finally its "fount of life" is revealed in a spherical, inert mass, single and undivided—the fertilized egg.

This fertilized egg is neither more nor less than a cell—specialized, as one would expect, for the discharge of its own particular duties, but still a cell. Here is a further strengthening of our view of the higher animal or metazoan as a colony of units each comparable with a protozoan.[3] When the method is traced by which the plurality of cells in the adult arises from the single cell of the egg—the method, that is, of cell-reproduction—it is found to be identical with one of the ways of reproduction in metazoan individuals, that of fission; the single founder of the cell-community, the egg, divides the whole of its substance into two halves, each of which is a new cell. This is repeated again and again, and the whole army of cells in the full-sized hydroid are direct descendants of that single founder-cell. But the hydroid is itself a founder; and the new "individuals" which it buds out depend for their growth upon this same process of cell-division continually repeated.

The paradox is growing yet. Each hydroid seems in its way a whole; yet it is as well a mere part of a single greater whole, the colony, and, besides this, itself composed of units each of which again is in some sort a whole: and each whole has some claim to the name of Individual.

One gap still yawns: what was the origin of the single cell that gave birth to the whole adult organism? In this particular case, it was a fertilized ovum: by which is implied that the single cell has arisen from the total fusion, body and soul, or rather cytoplasm and nucleus, of two other cells, these are technically known as the *gametes*, and their product, the fertilized ovum, as the *zygote*. These two cells have come from two separate individual persons (one male and one female) and their cell-ancestors have been firmly built into the fabric of those individuals' bodies.

This merging of two cells and their two individualities in one (the exact reverse of fission) is the essential sexual act, and is usually known as the *conjugation* of the two cells. It will be considered more fully later (p. 54); here it does not concern us, for, as Weismann and others have conclusively proved, reproduction and conjugation are in their origin totally distinct from each other. In all the Metazoa, however, conjugation is always connected with reproduction, so that the fusion of two cells always implies the production of a new individual. In ourselves, and all other Vertebrates, the converse also is true, that the production of a new individual always implies the previous fusion of two cells—reproduction, in other words, is always sexual: but in very many of the lower Metazoa, though conjugation leads to reproduction, reproduction may occur independently of conjugation. Two examples of this asexual reproduction have been seen in budding and in fission.

Thus the complication introduced by the fusion of the two gamete-cells into the otherwise unvaried succession of cell-divisions does not really affect the present question, the relation of one individual to another. The essential point lies in the continuity of individual with individual.

To add the final straw, regeneration comes. Regeneration is usually looked on as something strange, almost abnormal, owing to its not occurring in man or his animal familiars. In reality it is much rather an original property of life, which for special reasons has dropped out of the human scheme of things.

As we descend the vertebrate scale, it is not until we reach the lower Amphibia, such as the newt and salamander, that regeneration becomes at all marked. Even here it is present in a restricted form, and is confined to the restoring of lost organs. A leg, that is to say, or a tail, even an eye or a jaw may be replaced, but the central systems and main lines of organization must be left intact. There must remain a certain central residue of the individual if it is to complete itself.

This in itself points to a vaguer, more fluid notion of individuality than can ever be got from contemplation of man alone, but what are we to say of such things as happen in many of the lower animals? Take first one form of regeneration seen in Clavellina, one of those poor relations of Vertebrates, the Ascidians. Cut Clavellina across in the middle, and (in certain defined conditions) a bud will sprout from the front end of the hinder half, and another from the hinder end of the front half. As in the growth of the hydroid colony, the old organization is kept entire and whole, the new organization is built up in the bud; here, however, it is not one whole individual giving rise to another, but one half giving rise to just that dissimilar half which is its complement. What is more, both the unlike halves of the original whole can thus add what is wanting—that and no more—to bring them up to the rank of wholes again. There is an old school-boy question about a cricket bat:—suppose the handle of a bat broke, and a new one was put on to the old blade. Suppose then that the blade broke and was in its turn replaced; would the bat still be the same bat? That is a hard question, but Clavellina asks a harder still.

From this to the extremes of regeneration, such as occur among flatworms and protozoa, is another large step. Stentor, for instance (a protozoan which happens to be specially convenient for experimental purposes), may be chopped, broken, or shaken up into pieces of all sizes and shapes, and every piece, provided only that it is above a definite minimum size (less than 1/300 inch in diameter, and in bulk only 1 or 2 per cent. of a full-grown Stentor), and that it contains a piece of the nucleus, will blossom out as a minute but full-formed individual, which will feed and grow and be indistinguishable from a product of natural generation.

By now, all faith in man as a guide to individuality must have been shattered. In man, an individuality presents itself as something definite and separate from all others, something which animates a particular mass of matter and is inflexibly associated with it, appearing when it appears and vanishing only when it dies. That idea of individuality is not universally applicable.

In perplexing procession before us there have appeared individualities inhabiting single cells, others inhabiting single cells at the start, many cells (and each of these with some kind of separate inhabitant of its own) in later life: individualities whose fleshly mansions are continuous one with another, no boundaries between: individualities that appear and disappear along an undying stream of substance, the substance moulding itself to each as the water of a stream is moulded in turn to each hollow of its bed: within one individuality others infinite in number, lying hid under the magic cloak of potentiality, but each ready to spring out as if from nowhere should occasion offer.

Nothing remains but to abandon preconceived ideas. We must seek to interpret human individuality not as the one true pattern to which all others must conform, but as something with a history and intelligible only through that history. We must therefore make for the first beginnings of things and trace their upward progress. For this to be adequately done, the very fundamentals must be explored, and the quest begin with an enquiry into the original and essential properties of living substance.

The biologist, looking at life objectively, finds life then manifest itself as the sum of the properties pertaining to a group of peculiar and complicated chemical bodies which are classed together under the general name of protoplasm.

The form and structure adopted by the lowliest living things at the time of their origin, which then had to serve as the starting-point for all subsequent forms and structures in life, are chiefly due to two properties of these protoplasmic substances—one physical, the other chemical. The first is their colloidal nature, which permits of their sharing the definiteness and resistance of solids with the mobility and quick chemical reactions of liquids. The second is their power of assimilation, their power of building up, out of materials different from and chemically simpler than their own substance, new molecules, identical in composition with the old. Assimilation is molecular reproduction, and is by far the most important property of protoplasm. Whenever an organism performs any action, it must needs do work, expend energy. This energy it procures from the break-down and combination with oxygen of some of the unstable living molecules. Combustion is here associated with chemical decomposition: the result is not mere oxidized protoplasm, not protoplasm at all, but various more stable and more oxidized compounds. Every action thus necessitates the destruction of some of the living substance, and were it not for the assimilatory power, whereby it can pick up materials from the outer world and force them to assume a structure and arrangement like its own, all protoplasm would soon vanish into nothingness.

From these two fundamental properties of protoplasm we can understand three important and almost universal qualities of living things.[4] First their existence as definite bodies marked off in space and separate from other bodies, no mere formless collection of molecules, here to-day and gone to-morrow, like a liquid or a gas; secondly their power of movement; and thirdly their growth, due to their building up more protoplasm by assimilation than what they destroy in the production of energy. These three are all of importance in understanding the origin of organic individuality. Given cohesion of parts, your primeval organism is marked off from the rest of the world. Even though it may be homogeneous, no true system of diverse parts, yet this mere fact of existence as a single and separate material body is a first step towards Bergson's "closed system." In non-conscious animals, indeed, where individuality is bound down within the limits of physical substance, this separateness in space is the only foundation upon which such a closed system could be built. Besides this, it presents itself as a whole unit to the forces of the outer world: living substance thus starts with its foot upon the ladder leading to independence, for its molecules cohere, and all know that union is strength.

Given the complex molecules of fixed composition, and, if of various kinds, existing in a fixed proportion, there will be definiteness of shape and action; and given assimilation—the reproduction of new molecules identical with the old—there is the possibility of continuance for this shape and this action.

Analysed thus far, our organism has revealed itself as very similar to a crystal in its definite boundaries, definite and permanent form, and, we may add, in its capacity for growth. It differs only in having a mode of working as well as a form which is continuous.

The organism, however, has two further properties which make it at once more definite and more independent than the crystal. It is more independent, more self-determining, because it can build up its complicated molecules out of simple substances, and because these substances—its food—may be varied to a considerable extent and the end-result, its protoplasm, yet be the same. A crystal on the other hand, cannot build up the complex from the simple—it can only add ready-formed molecules to its substance, and can only use them if they are presented to it in one particular way, in the condition of a saturated solution.

An organism is more definite because its size is defined as well as its form. A crystal will continue to grow without limit if only the appropriate mother-liquor in which it hangs is kept saturated: its form is definite, its size indefinite. It is a fact of common observation, however, that each organism has a typical size—not invariable, but fixed within certain not very wide limits. This again is due to the differences in the modes of assimilation of crystal and living thing. In the crystal, growth takes place entirely at the surface. Its assimilation is purely physical: it assimilates to its own physical state molecules of the same chemical composition but in a physical state different from its own. Capturing molecules from their state of solution, it builds them up on its solid self in such wise that they fit on to the pattern of the already existing structure.

With protoplasm, however, assimilation is chemical as well as physical, and growth takes place by *intussusception*, not by accretion. That is to say, it works with raw materials,[5] and these materials, instead of being plastered on to the outside, can and do pass in to the interior, and only there are worked up into those combinations of brick and architect, the molecules of protoplasm. Thus, though the absorption of raw materials must of necessity take place at the surface, the actual formation of new living matter, or in other words assimilation and growth, goes on only in the interior.

As a further result of its partially fluid nature, protoplasm is subject to the laws of surface-tension, and a mass of it will therefore tend to become spherical. But in a sphere, as in any other solid body of fixed shape, surface increases with the square, bulk with the cube of the diameter. When we say that one ball is three times as big as another, we usually mean that its diameter is three times as long, forgetting, or leaving implied, that in surface it is nine times, in cubic content twenty-seven times as big. With our balls of living substance, this disproportion between increase of bulk and increase of surface brings difficulties.

Every molecule in the inner parts of the sphere must have oxygen and food if the whole is to go on living. As the organism grows, that is to say as its molecule-population increases, the demand of each molecule is no less, but, owing to the disproportion between surface and volume, the supply available for each is dwindling. The actual materials of supply still exist in unlimited quantity, but the organism cannot get at them. If the English Nation, with population advancing by leaps and bounds, were not able to build harbours and provide dock-labourers as quick as she bred men, all the wheat in Canada, with Imperial Preference to help, would not keep her from starvation, for the simple reason that it could not get in.

So the primeval drop of protoplasm, earliest ancestor of all living organisms, the English Nation not forgotten, found, as it grew, its ports and landing facilities not keeping place with the demands upon them. Each particle of food and oxygen has to be handled by the surface molecules—unloaded from the circumambient water, loaded up again into solution in the general protoplasm—before the central populace can feed or work; and for each four-fold increase of the transport workers there is a sixteen-fold increase within of the mouths to be fed. This cannot go on indefinitely: but what is to be done?

There are two alternatives. One is for the mass of protoplasm to continue its growth, but obviate the difficulty by spreading itself out in one plane. In such a film of uniform thickness, whatever its extent, surface and volume will increase in almost equal proportion. This method, though it has been used here and there, is not easy of adoption, nor wholly satisfactory when adopted. To obtain a thin film instead of an approximately spherical mass of protoplasm, the surface-tension must be very materially altered, and this implies a deep and continuous change in the condition of the surface layer as the size of the whole increases. For main result, the method has the suppression or at least the delaying of reproduction. Logically it leads to unlimited growth of the single mass of living matter, so putting all the eggs of the species in one basket; and even though it is certain that in such a flimsy unco-ordinated film parts would at length be accidentally torn off or simply pull apart from the main body, so reproducing and dispersing the species, yet this reproduction would be long delayed, and the change of structure which involved the delay would have brought few compensating advantages.

The other method is probably easier of adoption, certainly more beneficial in immediate result. It consists in this, that the disproportioned mass of protoplasm divides into two halves. By this means, though the total volume of living substance is left unaltered, the total surface it exposes is increased by over 50 per cent, and the two halves can thus go on gaily growing until the time comes to repeat the process. The actual division seems to be effected by a mere temporary lessening of surface-tension in certain regions, so that this would probably be the way of least resistance for the organism, the way that involved less deep-seated change than the first method. In its results it is certainly better. The species (by which is meant simply the kind of protoplasm), by the repeated formation and subsequent wandering away of new separate masses of protoplasm, is widely dispersed, so that it no longer presents a single neck by the severing of which some Nero of an accident could with one stroke exterminate the race.

It is thus almost entirely a direct result of the essential properties of protoplasm, scarcely at all an adaptation to outer conditions, that the earliest forms of life defined and limited their size;—in other words, that the first stable phase reached by life in her development on this earth was one in which she manifested herself as a succession of separate protoplasmic units, each formed from the bipartition of a former one, each beginning its existence as a rounded body of definite but always microscopic size, and each gradually growing, while preserving its form, till its volume was about doubled, when it divided and left its two halves to repeat the cycle. These, the primary units of life are usually called by the name of *cells*,[6] and the cell is the historical basis of organic individuality.

Protoplasm at its first appearance was presumably a homogeneous substance; as long as it remained so, these masses into which it segregated, however definite their size, their shape, and their reproduction, were yet not individuals. In their working they are like a host of other chemical substances, blindly forging ahead with their reactions, ceasing if the outer conditions transgress certain limits, continuing the same as long as they remain within those limits. They are not, in the strict biological sense of the word, *adapted* to their surroundings,[7] they are not adapted any more than such a cyclical or catalytic reaction as that which takes place in the manufacture of sulphuric acid from sulphur dioxide, water, and oxides of nitrogen. These, much after the fashion of protoplasm as it builds itself up and breaks itself down, the unstable intermediate substance, nitrosylsulphonic acid, must continually make, unmake, and remake itself. As long as the raw materials are present in the right proportions, the reaction will go on indefinitely. So it is with protoplasm: the conditions under which the inorganic reaction can take place are merely more restricted, so that for it to continue, man must step in with elaborate mechanisms to ensure adequate supplies of the substances concerned, provision for their due mixing, care for the removal of their by-products.

Any machinery that protoplasm makes for facilitating its reactions it must not only make itself, but actually out of itself. So it comes about that any improvement in working must mean some change in the structure of the protoplasm, and since improvement usually means division of labour, improved working brings with it a visible differentiation of parts in the previously homogeneous cell. What was a cell and nothing more is now a cell and an individual to boot.

Our primitive homogeneous masses of protoplasm, though all the evidence leads us to assume them, are purely hypothetical. Every cell that we know to-day contains at least three, and probably more, diverse and mutually helpful substances. There is the outer layer, whose primary function is absorption, though the secondary one of protection is often added. Its surface-tension and its solubility must be such that bodies which adhere to it and dissolve in it are useful to the whole cell as food. Within this outer sheath are two further substances. One, called chromatin on account of its affinity for many dyes, is chiefly concerned with assimilation, with the constructive part of the protoplasm's chemical cycle. Usually it is all massed to form (together with other substances) a definite body or *nucleus*, but in various primitive forms, such as some bacteria and some flagellates, it appears in the shape of minute granules scattered at random in the mass of the third substance, which constituting the bulk of the cell, is called the cytoplasm. This has as its special duty the destructive part of metabolism; it liberates energy, and uses that energy in doing work, such as locomotion, for the good of the cell as a whole.

All forms of life now living must have had an ancestor which existed under this double form of a cell and an individual, and it is our business now to trace the main lines of this development. Here is no necessity to enter into the causes of change; whether we believe in Natural Selection or Lamarckism, are driven back to Bergson's *élan vital*, or even to a complete confession of ignorance, is immaterial as long as we accept change as a fact. Then our task is merely to trace the change itself in its course and expose what to the best of our belief are the main steps it has taken.

Every organism has a general scheme of architecture which can be seen behind the mass of minor adaptive details. It is easy for instance to recognize the vertebrate plan in such different-looking creatures as a giraffe, a sparrow, and a sunfish, or the insect plan in butterflies and fleas. With such a plan to start from, change may work in three main ways. First, it may run through the variations on the original plan, without introducing any new complication. The different species of a genus, for instance, usually differ from each other in this way. Every one can recognize that polar bear and brown bear and grizzly bear are all built on the same bear-plan, though no one can say that one is better, more differentiated, than another. In the second way the original type of plan is retained, but complications are introduced which imply true differentiation of parts and division of labour; such parts have never been free and independent, so that the division of labour is very different, in origin especially, from that of insect communities or our human society, where the parts themselves begin as independent individuals. This is not mere change for change's sake, but change progressive. We may call this method *internal differentiation*, implying that all has taken place within the original unit. An architectural metaphor may help us. Life finds in the cell the ground-plan for her first mansion—a one-roomed hut. You may change your one-roomed plan from round to square, from square to oblong, and you will not have improved it: but add a chimney and windows, and at once, though still but one room, it is something better. Even a church with its aisles and nave, transepts and choir has grown thus by internal differentiation. In essence it must always be a single room so that the congregation may see and hear the service; and we realize the justice with which the Romans used *aedes* in the singular to mean a temple.

With equal justice they used the plural for a house. They had reached the stage of civilization when a house was no longer a single room, serving more ends than one at once, and all in turn, but a collection of rooms, each one different from any old single-roomed house, all modified in their architecture from being thus built up into a common whole, but none the less obviously separate rooms, each in itself a unit, each somehow comparable with the single space of the more primitive dwelling. This way, of joining unit with unit, is the third way with organic change. Suppose that instead of separating from each other after each division, the cells remain connected. The result will be a colony of cells each one like all its fellows. If division of labour sets in later among the cells, they are rendered mutually dependent, and the colony is transformed into a true individual, which is obviously of a higher order than the cell. It has attained what may be termed the second grade of individuality.

This method, for want of a better term, I shall call *aggregate differentiation*, to show that the individual formed by its means consists of an aggregation of smaller individuals. It differs from the second method in that division of labour, instead of taking place among the parts of a single unit, affects whole units or even groups of whole units.

This third method is of special importance for the evolution of life because those organisms that have adopted it have found the only satisfactory solution of that besetting problem—how to become large. It is of importance for the understanding of individuality because it gives the clue to many of the apparent paradoxes of the higher organisms or Metazoa—why they are built up of units comparable with free-living Protozoa, why they so often reproduce by means of a single cell, why the embryo produced from this single cell so often consists of a number of almost identical cells among which division of labour only later sets in.

Now that the animal has separate units to build with, each with a firm membrane and definite shape of its own, progress is much more rapid. In the first place, metabolism can be maintained in spite of increased size, since conducting channels for the food and waste-products can be constructed.

This would be all but impossible within the limits of an enlarged single cell, owing to the semi-fluid nature of its protoplasm; but now since each cell has a firm outer wall, by joining cell to cell tubes can be made through which the food and the waste-products can quickly pass from end to end of the organism instead of having to work gradually through by diffusion. At first, as in flatworms, most of the various systems of the body—the digestive, the genital, and the excretory—are themselves profusely branched, but later the whole business of distribution and collection is taken over by the circulatory system: this alone is ramified and the others can pursue their more proper avocations in peace.[8]

The nervous system is another which can be much more easily perfected in an individual of the second grade. To perform complicated actions which shall be appropriate to the circumstances, there must exist a nervous mechanism consisting of various parts, each part capable of being connected up with every other part. To evolve such a mechanism from a homogeneous mass of substance would no doubt be possible, but to evolve it from a collection of cells would be certainly easier, for there at the outset some of the essentials of the finished product—the separate parts and their discontinuity—would be already given.

Thus through reaching the second grade of individuality, life has been able to gain both size and brain-power for herself. And so it comes to pass that the next steps in her progress have been effected chiefly by the way of internal differentiation. All three ways of change were open to her, and all three have been used in their measure: but the main difficulty, the difficulty of size, has been removed from the path, and the second method can now show its full possibilities. As a matter of fact, the animals of largest size, of greatest intellect, and of best instinctive powers are all individuals of the second grade.[9] At the last, however, when the brain and sense-organs are sufficiently developed, life has gained her most elaborate triumphs of individuality by a return to the third method, of aggregate differentiation. How the method is now modified owing to the possession of a highly-developed brain by the units with which it works, will be treated of in Chap. V: every age has known and wondered at the results it has produced—the communities of bees and ants, and the societies of man himself.

Enough has been said to give the stranger in the land a general orientation, and to show him that Life will guide him to a better view-point than Man alone. The main outcome of the enquiry has been to show that living matter at its first appearance on earth, as the direct results of its material composition, could only express itself in the form of cells—rounded masses, microscopically small, each bound, after attaining a limit of size, to divide into two equal halves. Decreed thus by necessity at the outset, these cells are used ever afterwards as the words out of which all life's poems are fashioned. All living things are made of cells and of structures built by cells: all living action is reducible to cell-action. And it was no hyperbole to say that the English Nation is the direct descendant of an ancestor which throughout its life remained a single cell.

The cell was not from the outset an individual: but by its fixed limits of size, its defined shape, and its power of assimilation (by the combination of these properties, be it understood, and not by any one of them taken singly) it was the first thing evolved to which individuality could adhere. It was like Benjamin Franklin's kite, bringing lightning down from heaven, but it did more than that, for it provided a permanent resting-place on earth where individuality could stay, could gather strength and develop upwards. For this reason it is right to speak of the cell as the foundation of animal individuality. How in later times the relation of the cell to the individual is modified must be left for the present on one side (see pp. 104, 115): we must now retrace our footsteps and see how others have defined the animal individual.