THE EVOLUTION OF MIND

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THE EVOLUTION OF MIND

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INTRODUCTION

A RECENT student of zoology has urged that, in our selection of the distinctive marks of species, we should pay no less attention to mental differences than to variations in bodily structure. The adoption of this test might not appreciably alter the general scheme of zoological classification, but it would draw attention to a peculiar feature of the human species. The vast majority of the authorities have always maintained the specific unity of mankind. Fresh efforts are made in our day to disrupt it, at least with reference to the earliest prehistoric remains, but to most anthropologists it still seems that the differences between curly-haired and straight-haired, or between Paleolithic, Neolithic, and modern races, are not sharp and deep enough to constitute distinct species.

Yet this human species includes extremes of mental power more widely removed from each other than are the most divergent representatives of many genera, if not orders, of lower animals. The most dissimilar specimens of the sub-class of the Birds, for instance, do not differ from each other in frame so much as the Yahgan or the Aeta differs from the cultivated European in mental endowment. No doubt the difference is in essence one of corporeal structure; some variation in the finer texture of a part of the cerebral cortex, as physiologists would assume. But these features are as yet too obscure to be taken into account in classification.

Nor could we, in any case, make this vast diversity of minds a ground for multiplying species. The very nature of the human faculty has prevented the race from falling into sharply separated psychic groups. The countless shades of human mentality pass almost insensibly into each other, and they are, on the other hand, separated by a broad gulf from the most advanced of the lower animals. The invention of speech, the discovery of aids to travel, and the expansive impulses of commerce and politics, of missionary zeal, humanitarian sympathy, and scientific curiosity, have given fluidity to our culture, and prevented the crystallisation of the human elements in isolated groups. The frontiers of each psychic area have been crossed unceasingly in this flow of culture. In one age a horde of semi-civilised Teutons gazes across the Danube at the glittering civilisation of Rome; in another the soldiers and priests of Spain disturb the slumbers of a remote barbarism; in another the merchants of Holland and England break into the age-old life of a community of savages. To-day even a Thibetan priesthood, or an Arctic circle, fails to maintain its barrier.

In spite, however, of this recognition of the solidarity of the human family, we must not lose sight of the fact that it embraces an infinite variety of types. The ancient practice of regarding the human mind as one, and contrasting it with a no less artificially unified mind of the lower animal, was a most mischievous hindrance to progress. To-day we trace the slow descent from the mind of the trained thinker to the blurred mental vision of a Veddah, and then, after a gap that is partly filled by the skulls of the earliest prehistoric savages, retrace the lines in the activity of the highest mammals, and follow them until they are lost insensibly in the obscure processes of remote animals. Where shall we find a frame comprehensive enough to enclose this vast and varying assemblage?

In older days unity was sought by disregarding all but the broad features, or fundamental qualities, of mind. The outcome of it was a rigid antithesis of the intelligence of man and the instinct of the lower animal which is quite false to the facts as we now know them. It was the kind of artificial unity which, in pre-Darwinian days, was found in the whole sub-class of the Birds, for instance, if not in the whole class of the Vertebrates. In the biological trees which connected the various groups of animals at that time, only the divergent branchlets were real. The connecting branches and the common trunk were scientific fictions.

The discovery of evolution completely transformed the science of living things, and gave a massive solidity to the whole zoological system. We now find the trunk, or the broken fragments of the trunk, buried in the earth. We understand the ramifications of the tree of life as they were never understood before in the history of thought. We are slowly recovering the lines which connect the living and divergent types about us, through the common trunk and common root of millions of years ago. And there is every reason to expect that evolutionary research will do for psychology all that it has done for zoology. There is now no serious doubt among scientific men that, whatever the nature of mind may be, it has developed at equal pace with the material organism. Throughout the ages the procession of mental development has followed, or accompanied, so closely the procession of organic forms that we have a right to expect some such illumination in psychology, from our retracing of it, as has been obtained in zoology.

This is at once apparent in regard to that immense variety and graduated hierarchy of human intelligence of which I have spoken. Whether we consider it in the slow advance from feeblest infancy to maturity, or in the long ascent through the many cultural strata of a single city, or in the uneven levels of diverse races, it is interpreted more easily when it is illumined by the doctrine of evolution. The heavens do not more surely exhibit the successive phases in the making of a world than the scattered races of men illustrate the process of mental evolution. We begin to understand the wide stretch which separates the nebular mentality of a Yahgan or a Bushman from the coherence and brilliance of a Shakespeare, when we conceive it to represent æons of development. The primitive savage fell out of the march tens of thousands of years ago: the genius lives before his time. The lower types linger in the environment from which the higher have emerged. So do lower types linger throughout the animal kingdom; so you will find on many a countryside the lowly circle from which the ambitious stripling set out generations ago to reach the higher level.

Evolutionary research has, therefore, become a recognised implement of the psychologist, but it does not seem to be employed with a tithe of the assiduity which it deserves. This is partly due to the difficulty of the inquiry. Mind leaves no fossil impressions in the soil: not, at least, until the mind of man begins to embody its ideas in rough industry. Even of brain we have no impress until the skull is evolved in the fish, and then we have only the superficial indication of the empty brain-case. This difficulty, however, we may surmount, as will appear, by using the methods of zoology.

A more serious prejudice arises from the idealist complexion of psychology. It has retained so much of the spirit of its metaphysical lineage that it is still disposed to slight empirical methods. And a third, and even more serious, prejudice is the first principle that the "phenomena" which the psychologist studies are of a "different order" from all other phenomena. Reserving the point for fuller consideration, I need only observe here that the phrase is too ambiguous to have scientific value, and that it has been discredited time after time in the advance of science. "Vitality" once enjoyed that distinction. Ether and matter were, until a few years ago, said to be of different orders. A sudden illumination has shown that they are of the same order. It is the very characteristic of modern research to discover hidden connections between the most divergent realities. It is the supreme ideal of science to unify.

The outstanding difficulty in this coveted unification of the contents of the universe is the nature of mind. The latest discoveries of the physicist have provided an ample base for the unification of all material things. Formidable difficulties remain in the task of reconstructing the whole process of development, but hardly any competent authority now has any misgiving about the ultimate unification. The dominating question is whether we can bring mind into this unity, and the present essay is concerned entirely with that issue. It does not purport to be a contribution to psychology, since psychology disavows interest in such an issue. There have, however, always been two main theories of mind underlying psychological discussions: a theory that mind is an unique reality, unalterably distinct and remote in nature from the reality which we call matter, and a theory that mind is not a separate reality, but a different aspect of the same reality.

The issue of this work is, therefore, quite distinct, not only from that of modern psychological treatises but also from that of the work of Romanes, Lloyd

Morgan, and Hobhouse, which will at once occur to the reader. To their researches the writer has frequently to acknowledge his indebtedness, while frequently dissenting from their conclusions and interpretations, but they are mainly concerned to determine the precise degree and form of mind we may detect in the higher insects, birds, and non-human mammals. For my purpose this inquiry is subsidiary to a larger one, and I have given more attention to the earlier cosmic phase in which mind was slowly emerging, and to the final passage from the non-human to the highest human level of culture. I have had, therefore, to neglect much that was relevant from their different point of view, and to include much that they neglected, or has been discovered more recently. My aim is, in short, to bring together whatever facts may be found to bear on the subject in a dozen sciences—chiefly, physics, organic chemistry, geology, paleontology, zoology, physiology, psychology, and anthropology—and enable the reader to see whether the great advances which have recently been made in these branches of science have brought us any nearer to a verdict than we were in the days when monists, dualists, and parallelists fought their historic battles.

That there is good reason for reopening the inquiry from this fresh point of view, is at once apparent when one reflects that recent research has thrown light on some of its most delicate and critical stages. In the first place it has definitely removed the barrier which was formerly set up between the mind of man and the mind of other animals. Every fresh discovery of prehistoric remains—witness the recent discoveries at Heidelberg and Chapelle-aux-Saints—has confirmed the story of evolution, and it would be difficult, since the death of Rudolph Virchow, to name any anthropologist of distinction who hesitates to accept it. I do not name Dr. Alfred Russel Wallace only because, in spite of his broad and varied erudition, he nowhere assures us that he is acquainted with the immense and accredited material of prehistoric anthropology. The passage of mind from the non-human to the human level is assured, and recent physiologists have, as we shall see, done much to elucidate it.

At the other end of the scale of life another, and more obstinate, barrier has been removed. Whatever mind is in its simpler manifestations, it is not confined to the animal. Professor Darwin has recently ventured to say that "consciousness" is diffused through the vegetal as well as the animal world, and whatever reserve we make as to the term consciousness, we do assuredly find that whatever psychic qualities we may recognise in the lowest animals must be assigned also to the plant. We shall see that a simple physical principle accounts for the unequal development of this common inheritance in the two worlds of living things. Indeed we shall find that recent research has, in some important respects, pursued it into the inorganic world.

These discoveries have made it more important than ever to determine the precise nature of mind in the lowest organisms, and here again recent research has yielded a vast amount of material. Having some acquaintance with this province of microscopic work, I have carefully collated the studies of Engelmann, Pfeffer, Verworn, Strassburger, Binet, Loeb, Rhumbler, Radl, Jennings, and Le Dantec, and endeavoured to form a correct and adequate conception of "the psychic life of the Protist."

Between these two extremes—the province of the microbe and the province of man, the dawn of life and its culmination—runs the long story of the development of mind, and fresh light has been thrown on it by a score of contributory investigations. Experimental psychology has replaced the old animal-anecdotes by rigorous and systematic tests, which are applied to the worm and the starfish no less than the dog. Psychophysics has taught us much in regard to the relation of mind and brain. Anatomy has made great progress in the study of nerve, and physiology—witness the work of Preyer, Loeb, Starling, Verworn, &c.—has given us some most instructive results. Experimental embryology has obtained the most wonderful results, some of which have point for us. The life of the higher insects has been discussed afresh in a spirited controversy, which has at least afforded us a more exact knowledge of the activities of the ant, the wasp, and the bee. But the most interesting feature of this part of the inquiry is the study of the connection between geological changes and the more important advances in the evolution of organisms. We shall find that certain physical processes in the shaping of the planet itself have had a profound and too little appreciated effect on the development of mind. Finally, those prominent achievements of recent science, the analyses of the physicist and the syntheses of the organic chemist, will be found to have an instructive bearing on the inquiry.

Synthesis, a great educationist recently observed to the writer, is the most pressing need of our age. It will at least be granted that it cannot be without utility to make a provisional synthesis of these scattered investigations, and incorporate them in a survey of the development of mind through the succeeding and advancing populations of the earth. I have endeavoured to follow, as far as possible, the order of terrestrial evolution, not merely because this seems to be the more natural course for an evolutionary inquiry, but because it enables me the more easily to show the momentous influence which geological changes have had on the rise of new and higher animal types. It is another feature in which the present essay differs wholly from existing works on mental development.

Modest as is the design of making such a synthesis, and although the author has personal acquaintance with more than one stage of the inquiry, it has entailed so much labour that a word of personal explanation should be given. The problem of mind confronted me twenty years ago when I followed the lectures of Mgr. Mercier at Louvain University, and especially when I occupied a chair of Neo-Scholastic philosophy. From the Neo-Scholastic effort to clothe Thomas Aquinas in the ill-fitting garb of modern science I turned to German, English, and American psychologists. Ample and substantial as is the work they have done, the professed aim of their science exonerates them from the task of solving the cosmic problem of mind, which chiefly occupied me. I therefore approached the subject from the side of natural science, and leave the reader to judge what light may thus be obtained.

I formulate no dogmatic conclusion, and purpose only to make plain in what direction we are turned by these cumulative indications afforded by a dozen lines of research. In particular I wholly disclaim the ambition to put mechanical interpretations on the various phases of mental evolution. The issue, as it will be defined in the first chapter, is a broad one, and does not rest on these tentative and changing schemes. As, moreover, the work is not written from any departmental point of view or for any special class of readers, I have used, as far as possible, a plain untechnical language, and have, as the works indicated will acknowledge, sought aid in the whole relevant literature of Europe and America.

CHAPTER I

THE TWO EVOLUTIONARY SERIES

When the hope was first expressed that some light would be thrown on the nature of mind by the story of its evolution, our philosophical writers, who still exert a waning control over the ambitions of the sciences, fell to discussing the possibility. In the main, they frowned on the new expectation. There were not wanting writers, like the latest historian of German philosophy, Dr. Otto Gramzow, who candidly encouraged the hope,* but the great majority somewhat disdainfully concluded that the mere description of a process could not be expected, or admitted, to lift the veil from reality.

The position has been widely adopted, but it rests on a perverse and misleading statement of the case. If mind can be brought into the cosmic unity by tracing its gradual emergence from the etheric matrix—if the evidence suggests that it, no less than matter, is an evolutionary product of the dim abyss which modern physics is disclosing to us—a very important point will have been established. Most people are satisfied that a very luminous explanation

* *Geschichte der Philosophie seit Kant*, p. 497.

of the nature of matter is proposed in evolutionary physics. It is not too much to say that "matter," "energy," and "ether" have merged in a common element. If this new speculation be substantiated the light will spread more quickly over our mist-enfolded cosmos. In the same way, if the indications point to a similar mergence of mind in the primal element, ether, most people will agree that a good deal has been explained. A description of a process is always a description of a reality undergoing the process.

To discover if the evidence I have gathered points to this evolution of mind from ether, or if it points consistently anywhere, is the object of my inquiry, and I must first endeavour to give the clearest possible expression to the problem. The best way to do so will be to recall that we all admit two evolutionary series—the material and the spiritual, the evolution of things that have weight and measure, and the evolution of ideas and institutions that are founded on ideas. One may put it, briefly, that all who have the equipment to form a judgment on the question now admit the evolution of matter and the evolution of mind. And the question is: Do these two series represent the evolution of two distinct realities or of one and the same reality?

Let us consider first the material series. Until a few years ago the starting-point of the series in all discussion was the nebula. Modern astronomers are not so clear as they were on the nature of the initial chaotic mass from which our solar system has been slowly formed, but, seeing that there are more than a hundred thousand nebulæ in the space about us, and that a large proportion of them seem to be condensing into globes, the nebula is still a very general conception of the primeval chaos. Whether, however, the initial stage really was a vast cloud of extremely attenuated gas, or a colossal swarm of meteorites, or a great mist of finely divided liquid or solid particles, it is agreed that in some form the whole material of our system was at one time scattered thinly over thousands of millions of miles of space. It is agreed, too, that the pressure of the environing ether has in time moulded the mass into liquid and solid globes; whether or no it passed through a stage of white heat, whether the planetary masses were thrown off as rings, or spiral arms, or tidal bulges, is still under discussion. In the development of our nebula at least (whatever may have happened in other cases) smaller masses *were* detached from the central mass, and the first condition of life was afforded. The smaller globes were bound to cool at the surface millions of years before the central mass. Thus was provided a cool, firm theatre, irradiated with floods of heat, light, electric and actinic energy from the parent body, for the march of living things.

Those living things appeared in due course, compacted of the earth on which they moved, "chemical machines"—to use a phrase that is now common in scientific works—for the transmutation of simple energies into the subtle play of life. How the primitive living atoms clustered together to form larger frames; how division of labour set in among the clustering elements, and the various organs were formed for their special purposes; how, under the stress of internal impulse and ever-changing surroundings and mutual struggle, they slowly advanced to higher levels of organisation, and widened into the most wonderful diversity of structure, we shall gather as we proceed. Setting mind on one side for a moment, it is quite generally agreed among competent students that all this is a continuous story of the crystallisation of the primitive nebula; and the rest of the material universe, as far as we know it, consists of similar masses of matter, islands in an ocean of ether, at one or other phase in the process of cosmic crystallisation.

But recent discoveries have still further simplified our conception of the universe. The older theory reduced the visible world to an incalculable number of atoms of mysterious "elements," combining in mysterious ways to form the things with which we are familiar, and having mysterious relations to the ether in which they move. We have passed swiftly to another height of knowledge, and we begin to see—though it be still in the twilight —the real unity of the vast system.

Briefly—since the story is now familiar—we have strong ground to regard the atoms as formed out of the ether itself, as had long been suspected. The picture which the modern physicist suggests to us is one of extraordinary grandeur. It connects our diversified material cosmos into an ideal unity. The whole sweep of space over which the aided eye can roam, or the photographic film can reach—a stretch of at least 5000 billion miles—is filled with a continuous substance, whose enormously dense and elastic frame transmits its quivering pulses of light, and heat, and electricity at unimaginable speeds. Special students of this ether, like Sir Oliver Lodge, conceive it as a frictionless fluid of such density and energy that "every cubic millimeter possesses what, if it were matter, would be a mass of a thousand tons, and an energy equivalent to the output of a million-horse-power station for forty million years."* This is the basic substance of the cosmos.

In this fluid are formed minute and enduring centres of disturbance, with surrounding areas of stress, and these points or corpuscles (or electrons) cluster together in whirling constellations of from one thousand to a quarter of a million members. These groups, in which the circling electrons are separated by relatively vast distances, are the "atoms" of the older physicist; they are themselves so minute that, of the hydrogen-atoms (the smallest), 30,000 billions would find ample room in the space of a moderate-sized pin's head (or a cubic millimeter). They are evolutionary products of the ether, our seventy-three different types of atoms being probably the best-equipped survivors of many chance groupings of electrons. The varied quali-

* "The Ether of Space," p. 114.

ties with which they weave the elaborate pattern of the universe are determined by the number and arrangement of the particles of positive and negative electricity—possibly contrary and complementary disturbances in the ether—which enter into each atomic group. These minute systems then unite, apparently by electric action, into larger groups, or molecules: of which, in turn, there are thousands of millions in a microscopic blood-cell. The molecules unite, under the stress of the ether, in increasing masses to form the large material bodies with which we are familiar.

Thus, at bottom, our universe is a vast ocean of ether, punctuated by minute and intense disturbances, possibly due to vortices. These cause a stress in the surrounding ether, a source of energy which fills the world with infinite variety of movement. The minute points of disturbance unite in the infinitesimal systems which we call the atoms of matter, and fill the depths of space with cosmic dust. The dust gathers into meteorites and nebulæ, which slowly condense into flaming worlds, whose radiant energy may for millions of years quicken the surface of planetary bodies and spread over them a living filament of organisms. Formidable as the difficulties still are in the reconstruction of this evolution, the broad lines are generally accepted. All varieties of energy and matter rise out of the abysmal womb of ether.

Against this stupendous evolutionary series we set another that we call the evolution of mind. The imagination at once figures the mind, which has constructed this wonderful picture of the cosmos, as something quite apart from the system it is contemplating. Can we suppose that some especially large and intricate cluster of these swiftly-moving particles has somehow grown conscious of the structure of the vast system to which it belongs? Can the eye that ranges over that impressive panorama be regarded as a part of it, only differing from other parts in its greater complexity?

Here is, for most of us, the chief problem of mind. The truth is that a second evolutionary series set in when the earth reached a certain stage of its development. We grant an evolutionary unity of the whole spiritual world, just as we do of the material universe. Take science itself. We retrace the path of its growth through some centuries of recent European history, across the Pyrenees to Moorish Spain, through Arabia and Syria to ancient Alexandria, and on to more ancient Greece, Egypt, and Babylonia. We find in the end that science and philosophy are an evolved product of a primitive nebular intelligence, and we trace the component elements of this deep down in an earlier animal world. We follow art back until we come to the cave-dwellers of the late Paleolithic period, if not to the crude stone-workers of even earlier ages. We pursue religion until we find it melting in the mists of primitive animism or magic. We trace the highest codes of morality back to the rough rules that prehistoric men would be bound to evolve for the control of their early communal life. We retrace the growth of social institutions, industry, language, and all other expressions of human thought and emotion, until they merge in the same spiritual nebula of the mind of the primeval savage. It is much as if a vague mentality were diffused through the squat, savage, scattered population of the glacial or interglacial period, and all these glories of our civilisation had slowly crystallised out of it. Below and beyond it lies the more diffused and simpler element of animal mentality.

Without attempting for the moment to determine where mind begins, we have here the two evolutionary series in which the whole contents of the universe, as we know it, may be comprised. One represents, in familiar language, the evolution of matter; the other the evolution of mind. For the vast majority of men who have any scientific culture these two series embrace the whole world-process of which we are in any way conscious. There is, of course, even among men of science, a profound difference of opinion as to whether this cosmic process is controlled by a vast non-human intelligence, but that question does not come within the range of the present work. Apart from that issue, we know only two realities, "matter" and "mind." All the processes and beings that come within our purview, all that is or ever has been in the whole realm of dead or living nature, we regard as evolutionary manifestations of those two realities; and we now face the further question, which has very naturally been raised, whether they are two distinct realities at all, or only one.

Before I indicate the line of inquiry I propose to take, it is necessary to notice two groups of writers who will dissent from the very statement of the problem. One group consists of the idealists, who do not grant a reality to the material series at all, independently of the mental series. The other is a group of modern students who would substitute "energy" for "matter," or would at least insist on adding energy, or force, to matter. The language of both groups is so widely used in current literature that one is forced to consider it.

The quarrel with the Energists does not seriously affect this inquiry. Professor Ostwald, Professor Nyssens, and Dr. Le Bon, are, in different ways, the chief exponents of the view that energy is the one fundamental reality. As, however, they declare energy to be the common source or substance of matter and mind, they do effectually bring mind into the unity of the cosmos. The only question they raise for us is as to the propriety of speaking of the unifying reality as energy, or matter, or ether—a question of very subordinate interest. But there are a few other writers who would, like Lord Kelvin, make mind a separate reality, yet reduce matter to energy in the same way as the Energists. It is, in fact, a common practice to use the term "force" or "energy" substantively, and inexpert readers generally understand that matter and force are the fundamental realities of the physical world. Since the discovery of radio-activity and the dissemination of the idea that matter has been theoretically dissolved into ether (or electricity, as it is vaguely said), the confusion has become worse than ever.

The issue of this inquiry does not depend in any degree whatever on the settlement of this dispute, but it is advisable to offer an adequate authority for my declining to take force or energy in a substantive sense. It will be enough to quote a distinguished physicist, who is at the same time a strenuous supporter of the separate and distinctive reality of mind. "The question," says Sir Oliver Lodge, "how many fundamental entities in this sense there are, and what they are, is a difficult one . . . . Physical science, pushed to the last resort, would probably reply that, within its sphere of knowledge at the present stage, the fundamental entities are *ether* and *motion*."* Since motion is not a fundamental entity, but a condition of matter, Sir Oliver Lodge must mean that for the physicist the physical universe is reduced to ether in motion. Whether ether may or may not be described as material does not concern us. It is, as Sir Oliver Lodge says, a question of words. Ether has mass and inertia. It is enough for my purpose that physicists agree in regarding it as the one fundamental reality of the material universe. The definitions which they give of energy and force exclude the idea of

* "Life and Matter," p. 103. His criticism of Lord Kelvin will be found in *Nature*, July 2, 1908. See also his "Ether of Space," and an article in *Nature*, January 14, 1909.

substantiality, and reduce them to expressions of the relative position and work-capacity of matter or ether.

The other group of dissentients, the idealists, take far more serious exception to the idea of a twofold evolutionary series. If we are to accept literally the common statement of psychological writers—a statement which is not unfamiliar in works of natural science—that we know for certain only our states of consciousness, such an inquiry as this is discredited in advance. Possibly the day will come when students will look back with amazement on the duality of our literature; the pretension minutely to determine the parallax of stars which lie 500 billion miles away, the depicting of the earth as it was fifty million years before the human mind appeared, the feverish eagerness to reach the foundations of the material universe—and the bland assurance that we are merely examining our own states of consciousness, and that time and space and reality cannot be proved to be other than illusions. Since the day when Huxley so brilliantly reconstructed the early history of man, and so dogmatically insisted that we cannot break the confining circle of our mental states—when J. S. Mill so ably analysed the economic life of a concrete civilisation, and so firmly assured us that we know nothing but sensations and permanent possibilities of sensation—scientific literature has been invaded by this perplexing anomaly. Not only scientific men, but philosophic writers, have protested, yet the tradition is maintained in much of our most recent literature.*

Professor Villa represents idealism as the general teaching of psychologists, and if the bases of that theory are adequately presented in his "Contemporary Psychology," as well as in the works of Berkeley, Mill, Bradley, Royce, Sigward, Ward, and Mitchell, I am not unacquainted with them, but cannot discuss them here. I prefer to proceed on the assumption that the sun really is 92,000,000 miles away, and really has a temperature of some 7000° C.; that the Neanderthal skeleton is the material relic of a race that lived some hundred thousand years ago; and that the exquisite phrases which flash into my memory were not born there, but in the long-extinct spirit of a Shakespeare or a Goethe. Without this "naïve realism" astronomy and history and sociology seem to have little interest. If I do recognise in me at all a stream of states of consciousness, it is a stream firmly limited by enduring banks of personality. And I cannot conceive states without a reality of which they are states—not simply a reality "underlying" them—nor appearances (phenomena) without a reality which appears, nor feelings which nobody feels, nor presentations in which nothing is presented to nobody.

* See the protests, from the presidential chair of the British Association, of Sir A. Rücker (1901), Sir J. Dewar (1902), and Professor Rutherford (1909). For philosophic protests see Dr. Stout ("Analytical Psychology," i. p. 27, "Things and Sensations"), Professor Höffding ("Darwin and Modern Science," p. 449), and Professor Case (*Encyc. Brit.*, "Metaphysics").

The obstinate retention of the word "phenomena," in its philosophic sense, in scientific literature and the explicit idealism of some recent scientific writers oblige me to make this explanation. The problem I have in view is not, did mind create the cosmos, but, is mind an evolutionary product of the cosmos; not, is thought a secretion or distillation of the brain, but, are we compelled to seek for it a substratum other than the brain? Must we, in other words, trace the whole material evolutionary series to ether, but derive the mental evolutionary series from a totally different source? And the most promising line of research seems to be to study mind in its faintest and simplest beginnings, and follow its gradual unfolding until it issues in the human intelligence.

A very brief consideration of the human brain will make it clear that there is little hope of answering the question in any other way, in the present state of our knowledge. Imperfect as that knowledge is, we have very good reason to regard the cortex—the part especially developed in man—as particularly concerned in consciousness. The cortex is a layer of gray nerve-matter, varying from 1-6th to 1-12th of an inch in thickness, which spreads over the surface of the brain, following the outline of its curves and furrows. It is computed to contain 1,500,000 cells, or more, and the cells are built into a structure that is still far beyond the mastery of the histologist. We have, in fact, only the most slender knowledge which parts of this vast mechanism are associated with particular mental functions. And when we dissect and magnify a thin fragment of one of its chief convolutions, we can do little more than contemplate with amazement the infinity of fibrils or branchlets, which connect the cells in the tissue, and the extraordinarily intricate structure which results. Even to the most powerful microscope it is a world of mystery and incalculable potentiality.

If we then detach a single one of these cells with its spreading, tree-like outgrowths, we find that the cytologist is seriously puzzled as to its finer structure and possibilities. The nerve-cell, measuring from the 1-300th to 1-3000th of an inch in diameter, is built up of several hundred or thousand million particles of nerve-plasm. The architecture of the cell is still very largely hidden from us, and the chemical structure (or mode of combination) of each of its millions of molecular units is equally obscure. We have reason to believe that there are in each molecule of ordinary protoplasm at least 450 atoms of carbon, 720 atoms of hydrogen, 116 of nitrogen, 6 of sulphur, and 140 of oxygen.* Nerve-plasm is still more complex.

Recent discoveries have only increased the wonder and potentiality of the cortex. Each atom has proved to be a remarkable constellation of electrons, a colossal reservoir of energy. The atom of hydro-

* This is Hofmeister's estimate of the molecule of protoplasm. A few estimates are lower, but the various calculations usually assign about 1500 atoms to each molecule.

gen contains about 1000 electrons, the atom of carbon 12,000, the atom of nitrogen 14,000, the atom of oxygen 16,000, and the atom of sulphur 32,000. These electrons circulate within the infinitesimal space of the atom at a speed of from 10,000 to 90,000 miles a second. It would take 340,000 barrels of powder to impart to a bullet the speed with which some of these particles dart out of their groups. A gramme of hydrogen—a very tiny portion of the simplest gas—contains energy enough to lift a million tons more than a hundred yards.

Of these astounding arsenals of energy, the atoms, we have, on the lowest computation, at least 600 million billion in the cortex of the human brain. The atoms are built in an unknown fashion into molecules, the molecules are built up in an equally mysterious way into cells (possibly through intermediate clusters), and the cells are knit into the framework of the tissue in a way that still baffles us at many essential points. And the whole fabric is pervaded and held together by the cosmic fluid of which each cubic millimeter has "the equivalent of a thousand tons, and an energy equal to the output of a million-horse-power station for forty million years."

In the face of this great mystery and impressive potentiality it is, as yet, idle to speculate what the human brain may or may not be capable of doing. The declaration of Tyndall, so frequently applauded and repeated, that we will never know mind from a knowledge of the brain, is sheer dogmatism. Until we have penetrated some distance at least into the profound obscurity of the brain's structure and chemistry, we must avoid all such dogmatism, on either side. At present it is a dark cavern, in which the lamps of the anatomist and physiologist do little more than increase our sense of mystery. It is useless to say that it is or is not capable of any particular function as long as its structure is so scantily known. Nor can we set the processes of brain and mind in antithesis on the ground that they are of different orders; that one set is quantitative and the other qualitative. Many qualitative processes have turned out to be quantitative, or it is at least an open question; and to speak of different orders is to adopt a metaphysical device which has been often discredited.

We must approach the problem of the nature of mind from a different point of view. Direct subjection analysis of the human consciousness has been carried out with wonderful skill and success by modern psychology, but the psychologists themselves warn us that they are not attempting to explain the nature of mind as a reality. Even if all mysticism be discarded, indeed, we cannot hope to master the human mind by direct inquiry, as long as the anatomy and physiology of its organ are so little advanced. On the other hand, since both mind and brain are the culminations of evolutionary series, and we have in nature to-day, or in the fossil remains of the past, countless illustrations of the phases of their evolution, it is wiser to begin at the lowest point of the scale, determine accurately what mind is in its simplest expression, and trace the gradual differentiation of its functions. We must study it as we study the separate organs, or the distinct organisms, of the animal world; as we study language, social forms, morality, religion, and every other spiritual development. We must not expect the finished evolutionary product to reveal its secret until we have followed the slow process of its development.

CHAPTER II

THE LOWEST FORMS OF MIND

THE inquiry into the evolution of mind experiences at the outset a check of an apparently serious nature. The ideal procedure would be to study in succession the various types of mind that have appeared on the earth, and to fasten with the closest scrutiny on the earliest and most elementary types. It is not too much to say that the study of the most primitive forms is the most important point in the whole inquiry. Yet when we turn to the paleontologist for information on those forms, he tells us that the earlier chapters of the story of life have been irretrievably lost; that he cannot, from search in the fossil archives of the living family, give us even the remotest indication of the nature of its first representatives. At a certain level in the Pre-Cambrian rocks he begins to find shadowy traces of shell-fish and worms, and a little later he finds abundance of invertebrate life. But these types are relatively advanced. Organisms had been developing for millions of years before Brachiopods and Annelids came on the scene.

We have, however, only to turn to the biologist to learn at once the meaning of this enormous gap in the fossil record, and the way to find compensation for the loss. When, in the course of evolution, a higher type of animal has emerged from a lower group, the old environment remains suitable for the older and simpler type. When certain fish left the water for the land, the water remained as the habitat of fishes; when certain reptiles began to fly in the atmosphere, the land remained for the others; when the ape-ancestor of early man left the trees, the trees continued to find food and shelter for the apes. Over-population was relieved by the advance of some; the majority of the mother-group could fitly remain in the old home.

In this way nature has come to be peopled with a hierarchy of plants and animals, which, with many gaps, represents the procession of successive populations in the past. We descend to the lower grades of the biological scale, and we know that we approach the earliest forms of life. We then discover why the paleontologist finds no traces of their ancestors in the rocks. Until we rise to the Corals, the Echinoderms, the Crustacea, and the Molluscs, there are no hard parts of the body to be preserved in the primitive mud. Indeed, the very lowest animals do not—save for an occasional violent death—die at all in the sense of leaving an inert frame behind. The living cell divides into two living cells. Even long after some solidity of frame was reached and the dead body was entombed in the mud, the enormous pressure and the intense heat to which the early rocks were subjected would obliterate all the traces.

When, therefore, we would study mind in its simplest expression, we turn to the simplest forms of life which we find in nature to-day. These, happily, we need not go far to seek. The vase in which flowers have been left over long will furnish many types of elementary life (Bacteria and Protozoa). The moss-lined roof-gutter, after a shower of rain, the stems and leaves of water-plants, the surface and bottom of ponds and seas, even the inner recesses of the animal frame, will yield fresh and abundant representatives of this microscopic world. And the student will not carry his investigation very far before he discovers the entire inaccuracy of the popular notion that the animal differs from the plant in having an exclusive endowment of mind. Many of these minute organisms (Pandorina, Volvox, &c.) are claimed by both botanists and zoologists, so blurred is the dividing line between plant and animal. There are others, however, of undoubtedly vegetal character which behave in the same way as those of animal nature. It has been announced recently that animal and vegetal cells behave differently in the electric field—animal cells moving toward the positive and vegetal cells toward the negative pole.* Whether or no this be confirmed, the supposed psychic distinction between plant and animal has been wholly discredited.

* Professor Thornton in address to I Section, British Association, 1909.

Assuming for the moment that the term "mind" may fitly be applied to what are called the "psychic" activities of the lowest organisms, modern research has shown that it is a general property of living matter, whether plant or animal, when it has freedom of movement. The mobile Bacteria (the Bacilli and Spirilla), which are now generally regarded as vegetal, move spontaneously, and respond to stimulation, just as the Amœbæ and the lower Ciliata do. Even the spores of fungi and the antherozoids of ferns have revealed an almost equal sensitiveness. An antherozoid will move toward, or "select," a drop of malic acid, as an Amœba will. The same sensitiveness is found to some extent, in the Diatom and other plant-cells, and it is lost only to superficial view when we consider the familiar larger plants. Darwin showed long ago that the fly-catching sundew was, at the tips of its papillæ, sensitive to a particle of steel that weighed only the 1-78,000th part of a gramme. To-day, we know 500 different species of these insect-eating plants, and many of them show a fine sensitiveness.

Incidentally, it is instructive to say a word about the best known of the "sensitive" plants, the Mimosa. It is a purely physical mechanism, a system of jointed water-tubes for transmitting to the leaves the pressure of an invading insect. When the foraging ant, for instance, treads on the lower stem, its pressure sends the water up the delicate series of tubes, until the wave reaches the leaves and causes them to droop. There is good reason to suppose that this curious plant-mechanism has been evolved by natural selection to protect the leaves from the ant. As the mechanism is of large and visible construction, we do not now speak of its action as "psychic," but as "analogous" to sensitiveness. Is it not certain that if the structure were of molecular dimensions, and still inscrutable, we should credit it with "psychic" action?

Besides the sensitiveness of the capturing organs of the insectivorous plants, we have a good deal of sensitiveness to light in flowers and leaves (which has made "floral clocks" possible), a fine sensitiveness to moisture in the tips of roots, and an equally fine sense of gravitation in the tendrils of climbing plants. Professor Darwin does not hesitate to say that "consciousness" ranges throughout the whole plant world, as well as the animal world.* We shall find that the application of such words as "mind" and "consciousness" to the activities of lowly organisms is not without risk. We are apt to read our human experience with them. We may, however, safely say that such mind as is discoverable in the lowest animals is found equally well in the lower plants, and is strongly developed at certain points in the more advanced plant. In both plant and animal at that remote level there is sensitiveness—as exhibited by behaviour in response to stimuli—and spontaneous (or self-initiated) move-

* Presidential address to the British Association, 1908. On the whole subject see Francé's *Sinnesleben der Pflanzen* (1903).

ment. We shall see that these constitute all that we mean by mind in the lowest animals.

Whatever this elementary psychic quality is, therefore, it is a common property of living plasm, not an exclusive possession of the animal. Whether we can follow it still further down—into the inorganic world—we must not consider until we have made a closer study of its nature. One great principle, however, must be established before we proceed. It is now clear that the real distinction between plant and animal is related, not to any mystical quality, but to a simple physical difference. The plant has become sessile, rooting itself to the soil; the animal has developed locomotion. It is obvious that the development of sensitiveness would be, not merely useless, but actually disadvantageous in organisms that cannot move, and so the plant has generally forfeited its "psychic" power, and developed a thick protective skin. Only the plants which retain locomotion (Bacteria, Diatoms, Volvox, &c.), and those organs of plants to which it is especially useful, have preserved and cultivated the original power. The principle is as important as it is simple, and will aid us more than once in following the evolution of mind.

We have now to examine very closely the nature of this primitive psychic quality, as we find it in the most elementary organisms. The popular idea that unicellular beings are generally formless "blobs of jelly" is very far astray. Many thousands of species of these minute creatures lie below the line of ocular visibility, and they are separated into widely different types of structure. Some do indeed seem, even under the most powerful lens, to be formless and unorganised, though we must remember that the microscope cannot penetrate into their molecular structure; but other types have distinct "organella," and rise to an appreciable degree of organisation. We must, therefore, carefully guard against the idea that a study of any one group of these animals will inform us on the beginnings of mind. Such an inquiry as this must distinguish very carefully between the higher and lower Protists. Unfortunately, not one of the many brilliant investigators of "the psychic life of the Protists" has made a graduated study of mind through a series of these minute organisms, rising from the lowest to the highest, and I can only endeavour to make good the defect by selecting and re-arranging the results.

At the lowest limit of the scale of life we may place certain unicellular plant-cells of the Alga-type (Chromacea) and the nitrifying Bacteria. The bluish or greenish film which one so often sees on damp rocks or wood, dissolves in the microscope into myriads of minute bluish-green cells, often 1-10,000th of an inch in diameter, which the botanist calls the Cyanophyceæ. Highly magnified, they appear to be round structureless specks of plasm, absorbing their food from the surrounding moist matter, and dividing into two when they reach a certain size; but we must remember that protoplasm is a substance of remarkable complexity, and that the molecules of plasm may be built into a structure that the microscope cannot detect. Almost equally simple are the species of Bacteria which fix nitrogen in the soil, or in the roots of certain plants.

In these lowly and motionless cells there is no trace of anything that we should be tempted to describe as "psychic." We shall find our first traces of mind in spontaneous ("voluntary") movement and responsive movement to stimulation. These lowest vegetal cells can show neither form of movement. They may be stimulated only as artificial cells, made by the chemist, and other substances may be. To say that they may possess a sensitiveness which they cannot exhibit is idle assertion; to insist that they have mind *potentially* is merely to say, in different words, that the higher organisms were evolved from the lower. If we say that their protoplasm is "irritable," or capable of being affected by electrical or chemical agencies, we must remember that this is true even of metals, to say nothing of colloid compounds.

From this lowest level of microscopic life the unicellular plants and animals spread outward and upward in endless variety, and we quickly come to organisms with what is called "psychic" activity. From the nitrifying Bacteria and the Cocci we rise to the briskly moving Bacilli and Spirilla, with fine hair-like motor organs (cilia), and a high degree of sensitiveness. But—not forgetting that this power is well developed in the plant world—we may now confine our attention to the animal evolutionary series, and see how the sensitiveness increases with mobility and organisation. Even within a single cell there can be a very large amount of differentiation. Minute parts of the cell ("organella") take up definite functions, and we get some analogy to the division of labour in the higher animal body. To give even a general picture of the different types that ensue would be impossible here, but it is fortunately unnecessary. A few general observations on the normal life of the chief types of the Protozoa, on the movements they exhibit under artificial stimulation, and on the more striking claims that have been made for them, will suffice for our purpose.

The simplest type, the well-known Amœba, is a minute membranous sac filled with viscid plasm. It flows (like a sluggish drop of oil) over the field of the microscope, thrusting out blunt projections of its body-sac (pseudopods) in advance of its movement, and occasionally enclosing with them a particle of food. Under chemical, or mechanical, or other abnormal stimuli it rounds into a ball, like the disturbed hedge-hog. Amongst the higher Amœbæ the delicate membrane becomes a thick skin, and the projections of living matter (temporary limbs, &c.) take the form of finer fibrils thrust through permanent orifices. In higher groups of the Protozoa the protecting skin grows stronger, and even forms a flinty or calcareous or cellulose shell. The blunt projections give way to definite and permanent fine outgrowths, which act as oars. Some (Flagellata) have one or two stout lashes, like the oar of the gondolier; others (Ciliata) have row upon row of delicate hairs, like the banks of oars in an ancient galley. With these they travel incessantly through the water, absorbing food often at a minute gullet; under artificial stimulation the movement may be increased or lessened, or directed toward or from the source of stimulus. Some root themselves to the floor on long stalks, which are often contractile, and have rows of lashes (cilia) round their bell-like mouths, which bring the food in by making whirlpool movements in the water. Some have particularly sensitive patches on their skin (such as the "eye-spot" in *Euglena*); others have batteries of minute darts (trichocysts) to shoot at and paralyse their prey; others develop "armour-plating," like the curious shields of the "barrel-animalcule" (*Coleps*).*

We are not concerned here with the whole vital activity of these minute organisms. Numbers of students are working out a scientific interpretation of their movements, and if their suggestions are as yet vague and sketchy, we can hardly be surprised in view of our ignorance of the structure of the vital machine. A very large amount of structure may lurk below the level of the most powerful lens; and even when this is known, we have still—as is too often forgotten—to master the relations of its molecular parts to the surrounding ether. Hence, though these efforts may aid us, we have not here to determine the precise value of the mechanical theories that are offered to us. They may be replaced by

* See Calkins's "Protozoa" for full details.

others. The first question for us is whether there is anything in the normal or the stimulated movements of the Protozoa which compels, or disposes, us to credit them with consciousness.

It is often observed that in this interpretation of the activity of the lowest animals we have to use the standard of mind which we know best—our own mind. The plea is quite sound, but there are two precautions to be observed in applying that standard, as many forget. In the first place, since function follows structure, any "psychic" quality in the unicellular animal is likely to be as far removed from mental quality in us as their organisation is from ours. The second point is even more important. We are not only aware in ourselves of movements of will, intelligence, or emotion, but we know equally well that there is a vast amount of activity in us which does not involve consciousness at all. We have, in fact, in our person another of those graduated series which so well illustrate the evolutionary procession. We have, at the lowest level, the obviously physical activities of the body as such (gravitation, heat, &c.). We have then activities (of digestive and secretory cells, for instance) which depend on organic structure, yet are plainly physical or chemical. It has lately been discovered that even so purposive and obscure a function as the provision of milk in the mother at child-birth is of this order. Higher still we have such rhythmic activities as the beat of the heart and contraction of the muscles concerned in respiration; though both these are now claimed, on good ground, to be of the preceding order, or of a chemical nature. Above them, at all events, we have a multitude of nervous reflex actions, some of enormous complexity, by which an inherited mechanism performs purposive functions.

Now, we have the negative assurance of consciousness that these movements do not involve mind, but are the functions of evolved nervous mechanisms. It is too often forgotten that this negative witness of consciousness is as valid as the positive, and that we have to interpret the movements of lower animals in terms of our *whole* experience, not merely of our higher mental experience. Indeed, we must go much farther. Since the unconscious activities in our frame indisputably represent the earlier stages of evolution, it is particularly these that we should consult in interpreting the life of the most primitive organisms. Our viscera represent the early development of animal life; our spinal and peripheral nervous system reminds us of a later and higher stage; our brain, and especially the cortex of the cerebrum, belong to the later history of terrestrial life. If, then, we would seek analogies in ourselves to the activities of the simplest organisms, we should hardly look for them in the function of our late and elaborate brain.

When we examine the movements of the Protozoa in this light, we come to more sober conclusions than are reached by some students. Psychologists generally resolve mind into the ultimate elements of presentation, feeling, and volition, and if these processes are to be taken as something distinct from physico-chemical processes, we have no ground for attributing them to the Protozoa. The plain truth is that a good many serious students have been captivated, at the very threshold of the inquiry, by a specious metaphysical principle. They argue that, since mind does appear later in the evolutionary series, it must have been present from the start. Mr. Jennings, one of the ablest of recent investigators, openly asserts this, as we shall see. Principal Lloyd Morgan, perhaps the leading living authority on the animal mind (at least, the mind of the higher animal), reminds us seriously of the equivocal old adage, *Ex nihilo nihil*, and on that ground assumes that, besides the obvious physico-chemical "kinesis" (movements) in the Protozoa, there must be some not very intelligible "metakinesis," or rudiment of consciousness.

Now, if this principle were sound, we should be forced to say that social forms existed, somehow, in our non-social ancestors, and that religion and morality and art must have an "organic analogue" (as Professor Baldwin calls it) among the Amœbæ. I do not mean that these things must have existed "virtually" or "potentially," which is only a more pretentious way of saying that there were elements capable of producing them; but they must have been present in some shade of reality, or the adage fails. In truth, it does fail, throughout the whole process of evolution. It is one of the most familiar facts of science and nature that the regrouping of elements gives rise to wholly new properties—even properties "differing in kind" from those of the elements, Sir Oliver Lodge observes. These qualities are not made "out of nothing," but out of a combination of pre-existing qualities, which may be of a totally different order. And, surely, the formation of a central nervous system of the utmost complexity is pre-eminently one of those new combinations which we should expect to give rise to very distinctive properties. It is, we shall see, only when this centralised nervous system appears that most of the authorities find any trace of consciousness. Why, indeed, should we insist that mind must stretch back to the lowest levels of life, while we freely admit that its accompanying reality, the brain, does not in any sense whatever go below the worms?

The prepossession is at once misleading and unfounded. When we discard it, and study the movements of the Protozoa candidly, we see that they correspond, not to voluntary movement, but to one or other group of those lower non-conscious movements in our own frame, which it is more just and scientific to regard as parallel to them. The continuous creeping or flowing movement of the Amœba, the swimming of the Paramæcium, or the whirlpool-making of the Vorticella, no more implies the possession of will, in any form, than does the rhythmic beat of the heart, or the function of the medulla oblongata. In both these cases, as in the Protozoa, the movement is initiated within the mechanism itself. That the Protozoa halt repeatedly, or turn aside, requires no other explanation than the varied play of stimuli on their thin-skinned cells, or food-variations within the cell.* Their environment is a world of ever-changing pulses of mechanical, thermal, or chemical stimulation, and they respond as the unconscious cells in the human body do. The bending of their cilia is no more "voluntary" than is the action of the cilia in the human larynx or uterus.

If we then consider the abnormal, artificially stimulated movement of the Protozoa, we find that this gives us even less ground to grant them volition. The action of chemicals or electricity on their motor apparatus suggests of itself a mechanical nature, but we may go farther. A current of electricity sent through the water in which Ciliates are swimming will cause them all to head at once toward the positive pole; but it has the same effect on non-living, elongated particles. "The movement," says Professor Thornton, "has all the appearance of a forced mechanical action, similar to that obtained with inorganic matter." † Stimulation by means of light (in certain cases) has no greater implication; we have sensitiveness and response to light in fungi

* As Jennings and Lloyd Morgan admit. Lloyd Morgan ("Animal Behaviour, &c.") generally relies on Jennings and others for the facts of Protozoic life, and does not speak on it with personal authority. I should add that he avows the Monistic view, that mind and matter are aspects of one reality.

† In paper read to British Association, 1909.

(*e.g. Pilobolus*) and many flowers, and in inorganic matter. One of the finest instances is the thin rod of platinum in the bolometer, which responds to a ray of light that raises its temperature only the hundred-millionth of a degree.* Stimulation by heat, causing an acceleration or a cessation of ciliary action, according to its strength, obviously suggests a mechanical action. Chemical stimulation, in fine, does not in the least imply volition. If a capillary tube containing certain acids or salts is inserted in the field, the organisms are gradually attracted round and inside it; other acids and alcohol disperse them. Oxygen has always, and naturally, a strong attraction—to be more accurate, retains them when they find it—but even substances that are poisonous and fatal to them attract them, while wholesome foods (glycerine, for instance) do not.† This holds, moreover, not only of the Protozoa and Bacteria, but for the spores of fungi and the antherozoids of ferns and mosses. All the experiments on record have a distinct mechanical rather than psychic complexion. We may not be satisfied with the detailed mechanical interpretations offered by Le Dantec, or Radl, or Rhumbler,‡ but if we are to

* *L'évolution de la matière*, by G. Le Bon, p. 233. Le Bon adds that inorganic matter is endowed with an unconscious sensibility to which the conscious sensibility of no living thing can approach.

† Pfeffer, *Untersuchungen aus dem Botanischen Institut zu Tubingen*, Bd. II, p. 583: Verworn, *Psycho-physiologische Studien der Protisten*, p. 139.

‡ Le Dantec, *Traité de Biologie* (1903): Radl, *Untersuchungen über dem Phototropismus de Thierre* (1903);

pass any verdict at all, before the mechanism of the cell is fairly well known, we must say that all the evidence points to mechanical, not psychic, action —or suggests that in this case the two are identical.

Some writers have urged that we note in the Protozoa an amount of discrimination which points to elementary will. Some of the instances alleged are spurious. It is stated at times that the swimming Ciliates—we must remember that their movement is enormously magnified in the microscope—avoid collisions in a remarkable way. I have repeatedly put under the microscope a shred of vegetal matter with a score of Paramæcia and Colpods feeding on the Bacteria round it. They collided incessantly (especially the Paramæcia against the Colpods), with visible squeezing of their bodies. On the other hand, it is quite certain that particular Protozoa (*Vampyrella*, *Actinobolus*, &c.) select one kind of food out of many. Principal Lloyd Morgan has pointed out that such discrimination is a common feature in inorganic chemicals, and it is difficult to see any ground for wondering at it in organic chemicals. The world of the Protozoon is a world of "smell"—a world of chemical emanations—and, as chemical action is now generally regarded (like light-pulses) as electrical, we are in a better position to interpret these features of minute life. In any case, the preference of an Actinobolus for a Halteria as its food is on a level with the far more subtle

Rhumbler, *Archiv fur Entwickelungsmechanic der Organismen*, Bd. 7 (1898), pp. 103–345.

(yet chemical) attraction, at immense distance, of a female moth for the male.

Reserving for the moment certain special instances adduced by Mr. Jennings, we may conclude that the movements of the Protozoa must be compared rather with the movements of cells in a muscle or of ciliated cells in parts of the human epithelium, or of "white" cells in the blood; all of which are excluded from our psychic field. We must, of course, remember that, as nerve-cells specialise on sensitiveness in the higher animal, other cells may become *less* sensitive than the unicellular ancestor, in which the functions were diffused. This does not affect the analogy however. If we find in the higher body evolved motor-mechanisms (organs or cells) that perform complex purposive movements without the least relation to consciousness, we have no right to regard analogous movements in the Protozoa as "psychic," if we use that term in opposition to "physical." We have no reason to predicate "will" of the Protozoa in any other sense than as a modification of Schopenhauer's definition of will—the sum of impulses within a body moving it to action—a sense in which we may attribute "will" to the complex and discriminating atom of carbon.

The second psychic element, feeling, is even less discoverable in the lowest animals. Pleasure and pain it would be preposterously anthropomorphic to seek in them, but one or two students have claimed for them a semi-psychic "organic analogue of pleasure and pain," which retains a hesitating trace of mysticism. Dr. Jennings has pressed this claim in one of the ablest of recent studies of the Protozoa,* and as he is almost the only authoritative student of the Protists to oppose the prevailing chemico-physical view cf their activities, it will be well to examine his criticisms. It seems clear that he is influenced by the mischievous prepossession which I have already pointed out. "Any one," he says (p. 248)," who holds that we can account fully for the reaction of Euglena or Paramæcium, purely from the physico-chemical conditions, without taking into account any states of consciousness, must logically hold that we can do the same in man," and, conversely, those who admit pain in man must "look for it in the Protozoa." I have already pointed out the fallacy, or ambiguity, of this, and will only add that it evidently colours Dr. Jennings's whole study.

His main contention is that the Protozoa do not react as directly on stimuli (especially chemical) as the mechanical theorists usually hold. It is important to notice that his experiments were usually made on the more advanced Ciliates, and he admits that "in many organisms, doubtless, the reaction to light is of that direct character assumed to be general by Radl" (p. 70), and he found simpler reaction in the Bacteria. We should quite expect a less simple reaction in the more advanced cells. Possibly careful graduated study would reveal the whole series. In any case his experiments on the Hypo-

* "Contributions to the Study of the Behaviour of the Lower Organisms" (1904), and a series of earlier papers.

tricha (and partly on the Amœba) seem to show that the stimuli do not act directly on the motor-apparatus, but induce a change in the cell-body which leads to the modification of the cilia (or pseudopods). Why this change in the higher Protozoa, which is quite in harmony with the differentiation of parts in them, should transfer the process from the physico-chemical world is not at all clear. The higher animal body is full of indirect reactions which are not in the least psychic.

But Dr. Jennings declares that the "anatomical structure" of the Protozoa is unchanged in their reactions, while the "physiological state" changes; and he concludes that this physiological state is "the organic analogue of pain or pleasure." The answer is simple. No microscope has been yet invented that would reveal fine changes in the protoplasmic structure, nor would any physiologist entertain the idea of a physiological change without modification of structure. We may confidently say that the stimulus is bound to alter the fine structure of the cell in some way, and so lead to a physico-chemical reaction. There is not a tittle of evidence in Dr. Jennings's studies that pain or pleasure interposes. It must be recollected that some modern psychologists regard pain, not as the cause, but the effect, of what are usually called expressions of pain. We shall at least see that high up in the animal scale these expressions are most misleading. If Dr. Jennings has shown anything it is that in the higher Protozoa the reaction-process is less simple than had been supposed, and must be worked out afresh. To say that, on that account, it ceases to be physico-chemical, is hardly scientific; nor would the interposition of a psychic state help us in the least.*

A good deal could be written in disproof of the presence of feeling in the Protozoa—such as their "attraction" by deadly poisons, or to an electrode in a poisoned area—but it is enough to rule out the positive claim. We may speak of an organic analogue of feeling in the Protozoa, but there is no ground for saying that it is not a physico-chemical process. And when we turn to the third and last psychic element, presentation, we can only come to the same conclusion. Presentations, the elements out of which knowledge is finally built, are not easily defined. Our presentations are due to the reception of stimuli in very advanced organs of sense, and must be rigorously excluded from application to the lowest animals. We must adhere as closely as possible to the observed facts.

I will now take some of the more striking facts of

* The second part of Dr. Jennings's paper, a close study of the Amœba, is really an excellent rehabilitation of the physico-chemical school. He has, he says, reproduced the motion of Amœba, with "extraordinary" fidelity in drops of oil, and he gives admirable mechanical interpretations, with few lapses into anthropomorphism. But when he contends that they discriminate food and avoid obstacles, I submit plenty of personal experience to the contrary, and refer the reader to Verworn, who has found (p. 144) that even Protists with "eye-spots" do not avoid obstacles, and has determined by many experiments that the discrimination—which one would expect on chemical grounds—is very imperfect.

Protist life, to examine if they show elementary perception in any other than a physical sense. One of the most curious of normal movements is, to my mind, that of a "swan-animalcule" (*Dileptus anser*) passing along a weed, the long "neck" it thrusts out before it charged with darts (trichocysts—or coiled stinging threads) which it will discharge on fitting prey. With this may be compared the Actinobolus, resting with its filaments of plasm radiating on all sides to act only on one species of organism (Halteria). Dr. Jennings gives as his most remarkable experience the sight of an Amœba "pursuing" a smaller one, or an eatable cyst. In all these cases the spectacle in the microscope is interesting, but, on sober analysis, it is difficult to see where the chemical theory fails. It is, at least, quite as wonderful that an animalcule should evolve weapons of offence, which no one attributes to psychic action (or to any process different from that which evolved the shark's teeth), as that it should evolve a mechanism for discharging them on receiving a chemical stimulus from its prey. In the case of the Amœba Dr. Jennings admits that one pseudopod of the animal will attempt to reach (or be attracted to) an object in complete indifference, or even opposition, to the unstimulated rest of the body.

It is the same with Protozoa that "select" grains of sand to form a shell round them. Verworn showed by experiment that Difflugia exudes a sticky plasm, under the stimulus of contact, to which suitable and unsuitable particles adhere; but the unsuitable ones are brushed off as the animal travels. Mr. Headley credits the Zoothamnium (a colony of Protozoa on a contractile tree-like stalk) with "memory," or "power of learning," because it ceased to contract after he had shaken the tank three or four times.* It was more probably a case of fatigue; in any case, no one would credit simple Ciliates with such power of reasoning. In every case the allegation of "psychic" power (or power of a different order from the physico-chemical) fails. In every case there is reaction on particular stimuli, and, because the path of the stimulus is not plain and the reaction-mechanism is below the range of the microscope, the fact is elevated to "a different order." It is the very old and familiar fallacy of *omne ignotum pro mirifico.*

One point further must be noted before I sum up. Verworn conducted a very skilful series of experiments to determine how far detached portions of a Protozoan would behave like the whole animal. The result was remarkably suggestive. After a brief rest the segments commonly resumed their activity just as if they still formed part of the animal. Bits

* "Life and Evolution" (1906), p. 180. The chapter on mind in animals is below the level of the book. On one page (176) he gives the Protozoan "intelligence," and two pages later says, "it is difficult to say" if the same animalcule has "consciousness." He says the Infusoria "never cannon against one another," but I have watched them do it habitually. He holds that the Amœba absorbing a live Diatom and refusing a grain of flint cannot be a "matter of mere chemistry"; but the chemical stimulus must be vastly different in the two cases.

of Amœba, or detached pseudopods, crawled and ate like the whole Amœba. Bits of Ciliates lashed the water with their cilia as if they were still in place in the complete organism. The stalk of Vorticella went on contracting (as I have often seen it do) when the head (and therefore all reason for contracting) was gone. He found this true of "all, even the smallest, particles of the Protist-body."* These results have a very important bearing on the subject. As Verworn says, if there is any "psyche" in the Protozoan at all, there must be a "psyche" in each minute part of it; in other words, the psyche is the sum-total of the natural energies of a cluster of molecules of plasm (in Verworn's phrase, "biogens").

It is so very important to investigate the question of mind in the lowest animals, that I have dealt at some length with their vital activities. If, in conclusion, one decides to affirm that there is "mind" in the Protozoa, one must define the term precisely. In the first place, this "mind" is also found in vegetal cells like Bacteria, Euglena, Pandorina, Volvox, Diatoms, &c. In the next place, there is no reason to say that it means anything more than physico-chemical processes. The fact that consciousness does appear later in the story of animal evolution must not prejudice us, nor must we juggle with terms. If "psychic" means something distinct from physico-chemical processes, we are not justified in applying it to the Protozoa. This conclusion is independent of the value of actual mechanical inter-

* *Op. cit.* p. 177.

pretations of the phenomena, and I have preferred not to obscure the issue by entering into those explanations. The molecular mechanism of the Protozoa is very obscure. It is impossible to say that that mechanism is not adequate to account for their sensitiveness and response to stimuli and internally-initiated motion.

Two groups of the Protozoa, however, stand quite apart, and call for brief consideration. These are the unicellular animals which clothe themselves in flinty or calcareous shells, often of remarkable beauty—the Radiolaria and the Thalamophora. The flinty shells of the Radiolaria, especially, are often of such exquisite grace that even men of science have been tempted to wonder if there was not some dim æsthetic sense in the living animal. This view, of course, could only be held in a very wide, metaphorical sense. There are no eyes or visual organella in the Radiolaria, and it is difficult to see how anything short of an advanced eye could perceive these delicate structures.

The truth is that, though a few points in these pretty siliceous skeletons are still to be explained, we can fairly understand them on evolutionary, utilitarian principles. They consist essentially of a lattice-work round the soft body, which is obviously protective, and a series of spiny outgrowths, which serve to keep the animal afloat at or near the surface of the ocean. A false impression is often conveyed by the popular writer or lecturer, who selects a few of the more graceful forms for description. In the

4000 species of the Radiolaria there is an immense variety of form, the great majority having no beauty at all. I have specimens of hundreds of different species prepared by the master-hand of Professor Haeckel, yet I find that the inexpert observer gazes at most of them with complete indifference, and sees beauty only in the rare exceptions.

Evolution throws a clear light on the beauty of these skeletons, and quite excludes the idea of psychic action. The most primitive of the Radiolaria (the Colloidea) have no skeleton at all. They differ from the "sun-animalcules" (Heliozoa), from which they are most probably evolved, only in having a special band of firmer matter between the inner and outer layers of plasm. From these we pass to a group (Beloidea) in which the outer plasm begins to be meagrely protected with threads of silex, and then by definite flinty spicules. These useful spicules, under the influence of selection, band together and form a lattice-work. The protection is increased, and floating improved, when spiny outgrowths jut out from the lattice-work.

The three higher groups are built up on these simple principles. In the Acantharia the skeleton is built up of acanthin rods; in the Nassellaria the lower part of the lattice-work remains open to let out the animal's pseudopods, and is protected by a further series of outgrowths, while what seems to be a balancing organ evolves at the top; in the Phæodaria the skeleton is largely made up of light flinty tubes. If we arrange the 4000 species in their four divergent lines of evolution from the naked ancestor, we find every stage of simplicity and complexity, regularity and irregularity, leading up to the beauty of a *Lychnaspis* or a *Calocyclas*. And when we remember the countless myriads of these minute creatures that float in the ocean, and learn that the struggle has gone on amongst them for tens of millions of years—we find them in Cambrian deposits—we cannot wonder that selection has brought about some remarkable forms.

The contrast of the structure of the Thalamophora confirms this view. The chalk of which their skeleton is made does not crystallise into the exquisite angles and spear-points that we find in the Radiolaria, nor, as most of them do not float at the surface, do they need the same forest of outgrowths. The elementary form is a simple porous chalk sphere—porous to allow the pseudopods to seek food—with long needles when the animal must float. The higher groups are characterised by the possession of a shell with numbers of chambers—Nummulites has thousands of chambers in the diameter of an inch—coiled spirally round the centre. The principle of this arrangement is simple. The tiny speck of protoplasm grows out of its first shell, and the naked outgrowth covers itself with a fresh deposit. Again it grows out, and builds a fresh chamber, and so on, spirally, until the animal has reached its limit of growth. Here again we have a great number of varieties, illustrating the long story of evolution.

It is very important to bear in mind these remarkable achievements of a purely physical evolution. How the animal absorbs and deposits on its outer plasm the chalk or flint to build its skeleton, and why certain special symmetries are found in some of the Radiolaria (probably an effect of crystallisation), are problems still to be solved. But the introduction of a psychic power would explain nothing, and the broad plan is plainly due to physical principles. We have analogous facts in the last group of the Protozoa, the Sporozoa. Many of these parasitic animalcules have developed clinging and suctorial appliances of a very effective character. They no more point to psychic quality than do the hooks of the tape-worm or the claws of the tiger. They give abundant illustration of the efficacy of natural selection to produce elaborate purposive structures. There is no ground to say that the same unconscious processes may not have evolved the mechanism by which the motor-apparatus of a Paramæcium or a Stentor is enabled to respond to stimulation.

We have now to apply these principles to the reconstruction of the missing chapters in the story of evolution. Nowhere in the unicellular world do we find response to stimuli of a different order from the action of a score of mechanisms in our own body which work quite independently of consciousness. We have therefore no ground to attribute mind, in any degree, to the Protozoa. If we choose to apply the word "mind" to their processes, we must strip it of the distinctive significance it has in our own experience of states of consciousness. It would, no doubt, be much easier for us to consider mind as present from the first chapter of the story of life, arising from some mystic world that dispenses the investigator from pursuing it more closely, but we must adhere to the facts and face the difficulty of tracing, if we can, where and why consciousness does enter into the story.

The proposal will surprise many, but it is not novel. Verworn, and most of the leading authorities, do not admit mind in the Protozoa, except in the sense I have indicated. Professor Loeb refuses mind, not only to the Protozoa, but to the Cœlenterata and to most of the worm-groups. Indeed, we shall see that there are distinguished students who decline to recognise it even in the remarkable activities of the bee and the ant. We must build patiently on the foundation I have laid by this extensive study of the Protists. We find in them a sensitiveness, or power of receiving and responding to stimuli, which increases with their mobility. It is entirely wanting in the lowest, and does not even in the highest rise above the level of non-conscious activities in our own frame. The vast majority of the observations suggest that it is of a chemical nature, and we know that the cell is a chemical machine of the most extraordinary complexity.*

* Professor Thompson ("Studies of Animal Life," p. 217), applies the description "unconscious psychical processes" to the Protozoa, and would no doubt extend it. In that case we have, unless psychic merely means neural, a grave difficulty of definition.

But a further question should be briefly regarded before we proceed. Can this sensitiveness, or irritability, or response to stimuli, be traced beyond the frontiers of the living world? Do we find it in inorganic matter? Most certainly we find a very considerable degree of sensitiveness in inorganic bodies. Metallic instruments of the most exquisite power of responding to stimuli are now used by the physicist, and the chemist prepares films of extreme sensibility. Recently, indeed, a Hindoo student has made a series of researches which have disclosed an unexpected extension of sensitiveness. It had been established that the induction of electric currents by a stimulus was one of the surest criteria for distinguishing living from dead tissue. Professor Jagadis Chunder Bose employed this test, not only on plant-tissues (carrot, radish, geranium, lily, &c.), but also on rods of tin, and obtained the specific response. He further showed that metal can be fatigued, anæsthetised, or poisoned, as the plant or animal tissue may be. He claims that these curious experiments show the same irritability in the metal as in the organism.*

Other observers have come to similar conclusions as to the "life" of metals. It cannot, in fact, be doubted that sensitiveness is a widespread quality. The distinctive thing in the living body is not the reception of the stimulus, but the response to it. In this the isolated and mobile cell, poised in a fluid element, has an advantage over the rigid parts of a

* "Response in the Living and Non-living," 1902.

metallic machine, but it does not on that account cease to be of the order of mechanisms. The difference in molecular complexity between a rod of tin and a particle of plasm is enormous. If there is any different "order" at all, it is an order of magnitude. The molecular mechanism is too minute for us to follow its working. However, a dozen able students (Le Dantec, Loeb, Delage, Nägeli, Verworn, Rhumbler, &c.) are attempting to unravel its intricacy, and we may look forward to further illumination. Meantime, there are no facts which forbid us to go outside the range of the neural mechanism in search of an explanation.

CHAPTER III

THE EARLIEST FORMS OF LIFE

The analysis of the life of the Protozoa, which I have made in the preceding chapter, is, as I said, an indirect method of studying the earlier forms of life to appear on our planet. It may occur to many that, if we are not prepared to grant the presence of consciousness in these early organisms, there is no need to linger in that section of the story of life, but we may at once seek to determine where psychic activity, of the peculiar quality we know from our own consciousness, does begin. The inference is at fault. If these vital activities, the sensitiveness and spontaneous movement, of the lowest organisms lead gradually to the higher, they demand some further investigation. We must see how far modern science can enable us to reconstruct the earlier chapters of the story.

It is a fact of common knowledge that life had a definite beginning on our planet—that the planet itself, indeed, had a definite beginning. Every theory of cosmic development grants that there was a time when the material of our solar system was dispersed over a vast region of space. Whether it was dispersed in the shape of a gaseous nebula, as most astronomers believe, or as a swarm of countless meteorites, as Sir Norman Lockyer and a few others suppose, or as a cloud of cosmic dust, as a new school of geologists declare, it is not for us to consider. Nor does it concern us to discuss the extreme divergence of opinion as to the remoteness of this period of dispersal. Calculations based on geological grounds have ranged from 25 million to 700 million years. At one time physicists sought to restrict the figure on the ground of their measurement of the sun's heat, but the possibility of there being large quantities of radium in the sun has nullified their estimates. In fact, a new theory has arisen that the sun's heat is rather due to the dissociation of the larger chemical elements which stored up energy in the nebula, and we are told that the process may have gone on for "thousands of millions of years."*

Certain it is, at least, that in some far-off age this dispersed matter was gathered—probably under the stress of the surrounding ether—into a concentrated sphere or disc, and that the earth is a fragment separated in some way from the central mass. It is the general teaching of astronomers, and has hitherto been generally accepted by geologists, that the concentration of the dispersed matter raised it to a state of white heat, and so gives proof of the absence of life. Here, again, however, the accepted teaching is challenged by a new school, which would

* S. Arrhenius, "The Life of the Universe" (1909), ii. p. 240.

substitute a less violent concentration of solid or liquid particles (called "planetesimals") for the older and still general idea of a fiery mass of gas, gradually cooling and forming a crust at its surface.* It is not without significance that the new theory is confined to geologists. To the student of astronomy the knowledge that there are tens of thousands of luminous nebulæ in the heavens, half of them being condensing spiral masses of liquid fire; the fact that our hundred million stars, which have formed from nebulæ, are in a state of terrific incandescence; the spectacle of our incandescent parent-globe; and the high probability that the larger planets are still red-hot; and the significant flattening of the earth's poles, afford a massive basis for the prevailing theory which can hardly be shaken by a few dynamic difficulties. However, we are not concerned with this at present. Professor Chamberlin believes that the white hot matter, which he puts in the *centre* of the condensing earth, issued out through the porous strata, and poured over the surface. All admit that in those days there was no life on the earth, and that in the course of time life appeared.

As it is my aim rather to put a broad interpretation on the known facts of development than to

* The theory is best expounded in Chamberlin and Salisbury's "Geology" (1903), vol. ii. A number of geologists have followed it in denying the primitive incandescence of our globe. See Professor Gregory's address to the Geological Section of the British Association Meeting in 1907, Professor Coleman at the Meeting of 1909, and the discussion at the Geological Congress of 1904.

attempt a minute reconstruction of it, I pass briefly over the ingenious speculations that are offered us in regard to the origin of life. It is the general practice of modern biologists simply to assume that life was naturally developed, and the assumption is scientifically sound. Evolution ranges over the whole inorganic and organic worlds, and it is fair to assume that it rules in the obscure and remote passage of the one into the other, in the absence of any clear barrier to such passage. As the only opposition to this assumption is based on what are thought to be religious interests, students of science cannot take account of it.* On the other hand, we are so ignorant of the condition of our planet at the time when life appeared, that biologists are loth to speculate on the manner of its evolution. A very few words will suffice to indicate the lines on which special students of the obscure subject are proceeding.

Arrhenius has lately given a new form to an early conjecture of Lord Kelvin's that the germs of life may have come from another planet. It is now granted that the cold of space might not be fatal to germs of certain organisms, as was once thought.

* Even from this side the opposition is dying. Biologists like Professor Thompson and Principal Lloyd Morgan, who hold theistic views, believe that life was naturally evolved. The latter warns religious speculators that it "ill beseems us to build too much" on temporary scientific ignorance, and that "those who would single out from among the multitudinous differentiations of an evolving universe this alone for special interposition would seem to do little honour to the Divinity they profess to serve." ("The Interpretation of Nature," p. 77).

Sir James Dewar has pointed out, however, that such germs would be exposed also to the ultra-violet rays, and his experiments seem to show that this exposure would be fatal. In any case, the theory has little use. The early condition of our own planet is still so little known that we are quite unable to say that it was less capable than any other cosmic body of generating life.

Pflüger and Verworn have worked out a theory on the supposition that a radicle of cyanogen is the essential element in living matter. As cyanogen is (like the hydrocarbons and other constituents of plasm) produced at an intense heat, a basis for a theory is found in the early incandescence of the earth. Even Professor Chamberlin, we saw, grants the outpouring of white-hot matter from below, and the primitive masses of volcanic rock demand it in some form. In this white-hot stage we have a possibility of the production of cyanic compounds on a large scale; and the theory has the advantage of explaining why life is, it seems, produced spontaneously no longer (though a few distinguished biologists believe that it may be). Mr. Butler Burke suggests, somewhat differently, that a specific vital element may have been evolved from the etheric elements at the time when the other material substances were formed. Dr. Bastian points out that some of the materials of living matter (nitrate of ammonia) are formed in the air by thunder, and that there is ground to assume an intenser degree of atmospheric electricity in the primitive age of the earth.

These speculations can only be regarded as interesting or suggestive until our knowledge of the nature of plasm and of the primitive conditions increases. The materials of plasm were undoubtedly present in the shell of our planet, the air and sea-water, when its fiery surface (or lava-covered surface) cooled. There were then conditions of heat, electricity, and possibly radio-activity, which we know no longer, and from the point of view of science there is no hindrance to assuming that under these unknown conditions the elements entered into complex combinations, which culminated in the production of plasm. On either hypothesis of the primitive state of the earth there were vast quantities of carbon dioxide in the atmosphere—ejected volcanically on the planetesimal theory, left behind in condensation on the general theory—and, as Sir Oliver Lodge has well described, carbon and water are the keys to the chemistry of living matter. He points out that the evolution of a substance containing many molecules of carbon and water would lead to "the formation of a molecule consisting of thousands or hundreds of thousands of atoms, constituting substances more complex even than those already known to or analysable by organic chemistry," and that "such a grouping is likely to have properties differing not only in degree but in kind from the properties of simple substances." *

With these general indications of possibilities we must as yet be content. Organic chemistry has made

* "Life and Matter," pp. 185–6.

such vast strides in recent years that the mystery of living protoplasm promises to be solved. Chemical synthesis now produces 130,000 organic carbon-compounds, as compared with some hundreds produced in the laboratory of living nature. Carbohydrates are made artificially, and the attack on the more complex and important protein-molecule is making good progress. Professor Fischer, one of the greatest synthetic chemists, tells us that the "true foundation-stones of the protein-molecules" are the amino-acids; that the structure of all these, except diaminotrihydroxydodecanoic acid, is now mastered; and that all but three can be produced artificially.* Professor Armstrong, again, says that "the great problems of vital chemistry appear now no longer to be unattainable to our intelligence—their cryptic character seems to have disappeared almost suddenly." That this wonderful advance of organic chemistry has a profound bearing on the problem of the origin of life is strongly emphasised by Professor Armstrong. He believes that a "fortuitous occurrence" or "series of lucky accidents" may have led to the production of the necessary compounds, and adds: "When we contemplate the inherent simplicity of chemical change, and bear in mind that life seems but to depend on the simultaneous occurrence of a series of changes of a somewhat diverse order, it does not appear to be beyond the bounds of possibility to arrive at a broad under-

* Lecture to the Chemical Society, 1907, *Nature*, vol. 76 p. 651.

standing of the method of life."* He even ventures to suggest a way in which the "series of accidents" might have taken place on the primitive planet.

When we appreciate this enormous progress that organic chemistry has made in a few years, together with the discovery of the action of enzymes in the living body, and of the chemical nature of many vital functions that were only a few years ago widely removed from the domain of the chemist, we may expect before long to speculate more profitably on the origin of life. I have been content to indicate only the bases of the scientific assumption that life was evolved, and will now relate the order in which modern biology would, as far as is possible, conceive the advancing development of the primitive organisms.

Two points should be considered distinctly in regard to the formation of the earliest types of life. The first is the evolution of protoplasm itself; the second is the evolution of that individuality which even the lowest living things so markedly exhibit. On the first point I will go no further than the general suggestions I have already quoted from special students of the question. We await the further progress of organic chemistry. On the second point we are not so wholly restricted to conjecture. Many students have, of late years, produced artificial cells in which the individuality, at

* Presidential Address to the Chemical Section of the British Association, 1909, p. 29.

least, of the living cell is strikingly imitated. Whatever may be the true nature of Mr. Butler Burke's "radiobes," they—as well as the artificial cells made by Dubois, Bütschli, and others—prepare the way for an understanding of the differentiation of the primeval masses of plasm into distinct vital units. It must be remembered that the simplest forms of life have their vital functions diffused over their whole surface, and through the whole mass. It is believed that the lessening of the surface in proportion to the mass, as the animal grows, is the chief cause of it dividing into two, or reproducing. The greater the proportion of surface to volume, the more opportunity there is for feeding and stimulation.

It is not, of course, imagined that the earliest individuated particles of living plasm were comparable with even the Chromacea or the lowest Bacteria with which we are acquainted. For all we can say, simpler types may yet be found in nature, and they are certainly conceivable as earlier forerunners of the earliest Algæ and Bacteria. Since, however, even the highest Protozoa do not exhibit the presence of mind, as distinct from physical processes, we need not dwell here on that obscure early evolution. From some primitive type of life, which we may (on the analogy of the lowest Algæ and Bacteria) conceive as devoid of sensitiveness, several lines of higher development were started. In the waters of the primitive ocean the microscopic cellules gradually diverged into different types, and the ancestral sources of the Algæ, Fungi, Bacteria, Flagellates, Sarcodina (Amœbæ, Foraminifers, Heliozoa, Radiolaria), Ciliata, &c., came into existence. The affinities of these early groups are much disputed, and the question of their development does not concern our inquiry.* On the vegetal side were developed the primitive groups of the unicellular Algæ, Fungi, and Bacteria (of which we find the first positive traces in the Carboniferous). The Bacteria ramified into the thousand species we know. The Algæ and Fungi forfeited their rudimentary heritage of sensitiveness, as I have described, and the eventual passage of the former on to the land, and development into mosses, ferns, and higher plants does not concern us.

On the animal side at least three early types seem to have been developed, the Amœba, the Ciliate, and the Flagellate. From the common Amœba, or some such animal, we can fairly trace a line of development up to the Radiolaria and Foraminifers. Within the Amœba group the tendency is for the skin to become tougher, and the viscid plasm to penetrate this by permanent orifices in search of food. From this to the Heliozoa (or "sun-animalcules"), in which the plasm streams out in myriads of glistening rays, the step is intelligible; and I have

* Some derive the Bacteria from the lowest Algæ, the Flagellates from the Bacteria, and the other groups from different Algæ. Others think even the Bacteria a specially developed group. See Fischer's *Untersuchungen über den Bau der Cyanophyceen und Bacterien* (1897) and Schmidt and Weis's *Die Bakterien* (1902).

already explained how the Radiolaria may be derived from the Heliozoa. In the Ciliata the mobility of the primitive animal is at its greatest, and we find a corresponding increase of sensitiveness and special organisation. The Flagellata have a different means of locomotion—one or two stout lashes instead of a series of fine hairs—and have not advanced far. The parasitic Sporozoa may be left out of account.

With this general outline of the development of the unicellular world we may be content, and pass on to those higher animals whose frame is compacted of many cells (the Metazoa). Of these the Sponges are the lowest representatives, and they may be briefly dismissed from the inquiry. There is really no multicellular personality in the Sponges, and it is proposed to make of them an intermediate group called the Parazoa. The horny mass, with which everybody is familiar, is merely the common tenement of a colony of quite distinct unicellular animals. Such colonies are found (generally on tree-like stalks) among the Protozoa, and there is a fairly gradual advance toward the Sponge. Some of the Flagellates have a collar or cup surrounding the lash—a device for keeping the food-containing water near the skin—and the colonies of these Choano-flagellates come close to the most primitive type of Sponge, the Proterospongia.

From this primitive type the Sponges (which appear as early as the Ordovician period) branch out in three chief directions, according to the material of which their common tenement is made. In the common sponge it is horny, in another group it has a limy framework, and in the highest it is of flinty spicules, advancing in some to glassy structures of great beauty. But we must refrain from tracing their development—though there is, says Professor Minchin, "no group which illustrates so strikingly the theory of evolution"—because they show even less indication of the possession of "mind" than the higher Protozoa. Each animal in the colony is equivalent to a unicellular, and does not show as much sensitiveness as some of the Ciliates. The cell, especially the young and mobile cell, reacts on stimuli in much the same way as the Amœba. It is sensitive to light, and curls up at the prick of a needle. From our point of view, therefore, the Sponges may be associated with the Protozoa, and we must pass on to the Metazoa proper.

By what steps the passage took place in the pre-Cambrian ocean from unicellular to multicellular structure it is not ours to retrace. We have seen that there is a strong tendency to association among the Protozoa, and it may be added that the embryonic development of the higher animals is believed by many authorities to afford a clue to the process of advance. The germ of the higher animal breaks first into a cluster of cohering cells, and it is suggested that this is a reminiscence of the primeval forming of a multicellular animal, through the cohering of the cells after division. In any case, a roundish cluster of cells seems the most natural stage to assume, and we find such clusters to-day in nature (*Volvox*, *Magosphæra*, &c.). In these animals there is no advance in psychic quality. Each cell retains the diffused sensitiveness of the unicellular animal, and does not call for any closer study.

It is, in fact, obvious that we shall only find a fresh psychic quality when specialisation, or division of labour, sets in among the cohering units; when one cell develops specially the contractile power, and becomes a muscle-cell, another cell specialises on the work of digestion, and a third is released for the particular work of receiving and transmitting stimuli to the rest. The process is perfectly natural and intelligible. We shall even find colonies of multicellular animals (Hydractinia, Siphonophora, &c.) in which the different individuals have, quite unconsciously, been specially modified to discharge particular functions; just as we find, indeed, in the ant-world, or in the human world. This will mean that each cell will now develop in greater intensity one only of the qualities which fitted the primitive cell to discharge a variety of functions. The nerve-cell, or psychic cell, in particular, will exhibit an enhanced degree of sensitiveness to stimuli, and the mechanism for moving the body in response to the stimuli will be proportionately developed. The long story of psychic evolution will now commence afresh.

But we must remember the mechanical principle which we have already found to have an important influence on this evolution—the question of mobility or immobility. We saw that this principle offered alternate roads for the onward march at the very beginning of life. The plant settled in immobility, and failed to develop its sensitiveness or "irritability." The animal entered on the route of activity and developed that power of receiving and responding to stimuli which is so valuable a condition of travelling. We shall find that many a later group of animals stumbles upon the route of the plant world, and here, at the very beginning of Metazoic life, we have the divergence repeated.

The actual complexion of the animal world, and the first traces we have in the Cambrian rocks of its earlier populations, show that the primitive berry-like clusters of the earliest Metazoic world diverged in two different directions. One type (or group of types) maintained a free-swimming and active existence. Another type became stationary, or nearly stationary. The latter type has given us the Polyps, Hydræ, Corals, Jelly-fishes, and Anemones, which the zoologist (for a reason which does not concern us) classes together as the Cœlenterates. Except in the free-swimming Medusa we shall not expect any great psychic development in this large group, but it is necessary to glance at their "mental" qualities before we turn to the more promising line.

We find traces of these animals in the Cambrian (Graptolites) and Silurian (Corals) rocks, and may confidently picture to ourselves a vast and varying abundance of them on the floor and in the waters of the primitive ocean. Most of them, however, have bodies too soft to be preserved, and we are forced to study their modern descendants. Of these one of the simplest and most easily obtainable is the Hydra, the octopus of pond-life, a minute creature which seems at first sight to be nearly all stomach and outstretched arms for stinging and capturing its prey. Flatten the animal, while outstretched, under a glass plate, and its body is seen to be built of a double wall of distinct cells. On finer examination it is found that certain cells between the two layers are specialised nerve-cells. Not only are the inner cells now taken up with digestion, and the outer cells distinctly muscular, but this third type of small cell is particularly devoted to psychic work —to the reception and transmission of stimuli. In addition the wreath of waving arms round the mouth are provided with stinging cells.

This is the typical structure of the lower Metazoa. The Anemone will be recognised as a larger and more stumpy type, with more numerous arms. The Coral—the single individual of the coral-colony—has essentially the same build with a stronger gullet. The Medusa is an inverted structure, with its body expanded into a muscular umbrella, and the arms streaming below. There is reason, in the embryology of the Medusa, to think that it is a branch of the family which returned to active ways; just as the whale has reverted to the habits of its remote fish-ancestor. The lower jelly-fish begins its career as a fixed polyp. But the only point of structure that concerns us in this interesting group is nerve-structure. In the Hydra we have the rudimentary condition of a few scattered nerve-cells, and the Coral, which may have degenerated in nerve as it became quite sessile, is even less advanced. In the Anemone we find that these nerve-cells form a continuous layer under the ectoderm (outer layer). In the active Medusa we find, as is natural, the highest development. The sensitive cells are clustered in regular masses, or are disposed in continuous rings round the edge of the umbrella, and there are the first rudimentary sense-organs.

In approaching the task of interpreting the behaviour of these lowly animals, we must recall the principles which we have already recognised. Advance in organisation means the evolving of mechanisms by which the animal can better adapt itself, or adjust its behaviour, to its environment. As the primary need is still the acquisition of food and the avoidance of other feeders, any advance will take the form of a finer mechanism for receiving stimuli and responding by an appropriate movement. The first quality is gained by the intensification of sensibility, or irritability, in the nerve-cell; and the more these cells cohere and are interconnected, the more effective will be the appreciation of the stimuli. If the nerve-cells further specialise on different stimuli, and we get distinct sense-cells, the machinery will be all the more effective. Moreover, such increase of sensibility would be worse than useless unless the sensitive cells were in close communication with the executive—the muscles—of the animal. If, therefore, there is any truth whatever in natural selection, we shall expect a neuro-muscular mechanism of this kind to be gradually produced.

The special tone of a nerve-cell offers no greater difficulty to an evolutionist than the special quality of a muscular or digestive cell, and the grouping of the cells into rings or ganglia is a distinct mechanical advantage. The principle is still the same when some of these cells become, in association with pigment-cells (to arrest the light and increase its stimulus), particularly sensitive to certain etheric impulses, and we get the ocelli (rudimentary eyes) of the higher Medusæ; or when a particular cluster is found to form a sensitive bed for a stone, which rolls from side to side as the animal inclines in one direction or other, or is affected by waves of air or water. These are nervous mechanisms of the same order as a score of nervous mechanisms in the human frame which we know to act quite independently of consciousness. No feature of them is clearly beyond the range of a mechanical evolution, or a selecting of useful structures, as they arise, by the normal agencies of evolution.*

In other words, the normal life of the Cœlenterate organism gives no more proof of the action of any other than physico-chemical processes than the

* I wish throughout to use a language which is consistent with all the chief schools of evolution, and not to rely on any special theory of it. It does not concern this inquiry whether the evolution was continuous or discontinuous, directed or not directed; nor what was the cause of variation, or whether acquired modifications are transmitted.

life of a Ciliate did. Their generally correct response to different stimuli testifies to the comparative efficiency of their neuro-muscular apparatus (without which they would not have survived), and is not more striking than similar mechanical responses in the unconscious human frame, or in an animal from which the brain has been removed. Hardly any one would question this as far as the Hydra and the Coral are concerned, but a claim is often made for "dim consciousness" in the Anemone and Jelly-fish, and we must consider the evidence for the claim.

Romanes, the finest of the early students of animal intelligence, believed that he had found evidence of its presence in the Anemone. Before describing his experiment, let us see how he defines the criteria of "mind" in his "Mental Evolution in Animals." He finds his best test in "variable and incalculable" action, as opposed to the fixed and calculable action of a nervous mechanism; or, as he more fully defines it, "adaptive action by a living organism in cases where the inherited machinery of the nervous system does not furnish data for our prevision of what the adaptive action must be" (p. 18). The obvious weakness of this definition is, firstly, that we know comparatively little about nervous systems beyond their superficial anatomy; and secondly, that it will be extremely difficult to fix the limit of variability, since the action of a nervous mechanism will vary with the stimuli. And when Romanes goes on to say, more precisely, that "choice," or "discrimination between stimuli" is the readiest test, he is even less successful, as Principal Lloyd Morgan has pointed out. Chemicals "choose" and "discriminate" between stimuli. An elaborate chemical machine should do so most effectively.

We see the failure of this test at once when we consider Romanes's application of it to the Anemone. He directed a fine jet of water on one of these animals in a tank. At first it was confused by the stimulus, but after a time it would open out in the jet, and close on a solid body while ignoring the current of water. It is curious to find that Romanes goes on himself to point out how sensitive plants, like the Dionæa and the Drosera, will discriminate, even more remarkably than this, between particles of food and uneatable particles placed on them. There is no more need of dim consciousness in one than the other. Discrimination between stimuli is precisely what we should expect if chemistry is at the basis of life.

And that the discrimination of the Anemone does not go beyond these limits has been clearly shown by the experiments of Professor Loeb. Romanes has himself observed that the neuro-muscular mechanism of the stomach behaves with such discrimination that, if the stomach were a distinct organism, we "might be in danger of regarding it as dimly intelligent." We are guarded from such an interpretation by the negative testimony of our own consciousness. The stomach is a chemical mechanism, and not the most wonderful in the economy of the body. Professor Loeb's experiments go far to show that the lower animals, such as the Cœlenterates and lower Worms, are similar mechanisms. The inexpert reader shrinks from the use of the word "machine" in connection with living things, but the prejudice is quite unreasonable. To-day we have even metallic mechanisms which exhibit a degree of sensitiveness, or response to stimuli, that offers a remarkable parallel to nerve-action. But a machine not of rigid metal, but of colloid chemicals, must have far greater possibilities. The simple mechanism of the film on a photographic plate will respond to stimuli, and so register remote stars and nebulæ, which the eye cannot appreciate. In higher physics even more delicate chemical mechanisms are used.

Loeb first tried the experiment of giving bits of crab-meat and bits of pulpy paper to an Anemone (*Actinia equina*). The tentacles at once allowed the meat to slide upon the mouth, the sphincter-muscle was relaxed, and the meat was digested. The paper evoked no response whatever. Here, assuredly, is a discrimination between stimuli, but it is quite obvious that a mechanism formed to react on a chemical stimulus would need no "dim consciousness" (which would, in fact, not help the matter) to discriminate between the two. But Loeb. a brilliant and fertile experimenter, went much further. He found that on making an incision in the body of the Anemone, a fringe of tentacles developed round the edge of the cut. These tentacles seized the meat, and pressed it against what ought to be—but generally was not—a mouth. When the slit was made near the real mouth of the animal, the new tentacles struggled with the normal ones for the food. When the body was cut across, and a new mouth appeared at the aboral end, the animal fed at both ends, but the aboral aperture would admit the pulpy paper; and the first mouth would eject as soon as the second started eating. Professor Parker further showed that, when a single tentacle was cut off, it would still grasp food, and press it in the direction in which the mouth ought to be. Finally, Professor Loeb found that the stimulus of gravitation was not less effective. An Anemone turned upside down will right itself in the course of an hour. If the Anemone—caught in a wire net, for instance—be then inverted again, the body will slowly bend in a second loop in obedience to the stimulus of gravitation.*

Similar experiments were made on other Cœlenterates. It is well known that if a Hydra be cut in pieces, each fragment may become an entire Hydra. In these lowly animals, at least, a distinct set of "determinants" in the germ is not necessary. Professor Loeb found that if he cut a cube out of the body of a Hydrozoan, the top part of the cube developed arms, and the lower part rootlets, quite irrespective of the original position of the cube in the body. If the developing fragments were inverted,

* "Comparative Physiology of the Brain and Comparative Psychology," pp. 48–60 (1901).

tentacles would now grow alongside of the previous roots, and roots with the tentacles at the other end. These very remarkable experiments—which we shall find repeated even on higher animals—well illustrate the mechanical nature of the lower Cœlenterates. Their discrimination of food is, to say the least, quite consistent with the view that they are mere chemical mechanisms, and no other indication of consciousness, however dim, has been claimed in them; while these ingenious experiments strongly favour, if they do not establish, the mechanical view.

Passing over, then, the various groups of Polyps, Hydrozoa, Corallines, Corals, and Anemones, we have only the Medusa to consider. In the higher Jelly-fishes the responsive mechanism is greatly advanced, but there is no serious claim for indications of consciousness. The normal and rhythmic contractions of the muscular umbrella—for the purpose of locomotion—are comparable to the rhythmic contractions of the heart or the respiratory muscles. The only claim I find of something higher than a physical process is that, if you touch the Medusa at any part with a pencil, it will move the "handle" of its umbrella to the spot. The movement is so closely parallel to the action of a decapitated frog, in brushing a spot of acid from its body, that it cannot seriously be regarded as an indication of a psychic process.

Professor Loeb claims, in fact, to have shown that the movement of the Medusa, like the beat of the heart, to which I have compared it, is of a more directly chemical nature than is generally believed. He found that when the chain of nerve-ganglia was removed, the pulse of the muscles stopped, as had been observed before. But he found further that, if the mutilated Jelly-fish were put in a certain saline solution, the movement recommenced, in spite of the absence of nerve. He then tried the same experiment on the vertebrate heart, with remarkable success. He concluded that the ions (particles charged with electricity) in the water (or in food) effected the movement, and that nerve-ganglia have not the co-ordinating function assigned to them.

The latter point will have to be considered with great caution when we pass to higher animals, but we may conclude that the claim of the presence of any other than physico-chemical processes in the Cœlenterates is by no means substantiated, while the opposing experiments have great force. In the second stage of the history of life, when the primitive ocean swarmed with bell-like Medusæ, and its floor was studded with brilliant Anemones and Tubularies, or humble Polyps, or clustered colonies of Corals, mind had not yet appeared; if we insist that mind is something of a different order from chemical processes. A nervous mechanism was being slowly evolved for the more intense reception of warning stimuli, but the sessile habits of most of this generation surrendered the promise of progress. Not without some reason did the older naturalists name them "Animal-plants" (zoophytes).

They developed the roots and the radiating arms of the plant, and condemned their posterity to lowliness. Only in the free-swimming Medusa does the progressive element appear, but we have no idea at what epoch the Medusa was developed. In its active frame the need for a power of responding to stimuli was greater. The sensitive cells concentrated in clusters and bands, or differentiated into special organs of sense.

We need not linger over the ocelli and otocysts of the Medusa, as the problem will recur in the next and more progressive group, but I will in conclusion notice a special group of the Jelly-fishes, which disposes us to appreciate the capabilities of unconscious evolution. In this group, the Siphonophores, there has been an adaptation, quite independent of consciousness, yet quite as remarkable as the neuro-muscular apparatus of the most advanced Jelly-fish. They are, in the opinion of most zoologists—though their communal nature is not unquestioned—colonies of Medusæ, in which different individuals have developed into special organs. One may become the float of the community, others the swimming muscles, others the feelers (palpi), the mouth, the sex-glands, or the stinging-batteries of the colony! In the graceful and beautifully-coloured *Disconalia* we have such a colony in the space of half a crown. In the *Salacia* we have a succession of similar colonies on a long stalk, all developed from one ovum.

These Siphonophores often have the appearance of flowers, as they float at the surface of the ocean.

The flower, indeed, all the parts of which are transformed leaves, is an excellent illustration of the way in which—whether we regard the organs as distinct individuals or no—unconscious selection has brought about their curious and purposive arrangement. In the lower Polyps and Hydrozoa we have many colonies with a similar, but less perfect, differentiation. We are, therefore, not straining the resources of nature in conceiving that a highly adaptive neuro-muscular mechanism could be evolved to discharge what are called the "psychic" functions of these lower animals. Principal Lloyd Morgan says that, if they have a dim consciousness, it probably merely *accompanies* their movements. So superfluous a quality cannot be postulated, except in virtue of the sophistical adage, *Ex nihilo nihil*, which belongs to the airy region of metaphysics rather than the solid ground of science.

CHAPTER IV

THE APPEARANCE OF BRAIN

In the primitive ocean, we saw, one great group of the early multicellular animals settled sluggishly on the floor, and became "Animal-plants." Their higher vitality spent itself in the development of long arms or tentacles, with which to grasp their prey, or sting their foe, or bring the food in whirlpool currents to the open mouth. They forfeited the chance of progress which is inherent in the living organism. But another group of these primitive globular animals retained their activity, and improved their organs of locomotion, that they might the better pursue or escape pursuit. The struggle would deepen with the increase of life. The land as yet offered no escape from the watery battle; the warm ocean—we find corals in all latitudes—had a tropical fertility.

In this primitive struggle the great qualities to attain were speed and perceptiveness, and it is not difficult to imagine how the organism was gradually shaped so as to secure the advantage. The prehistoric boat was a clumsy contrivance; half a tree-trunk, roughly hollowed with fire and stone axe, uneven, and without pointed stem or guiding stern.

Under pressure of the need to obtain speed it has evolved into the evenly balanced modern racer, with its finely pointed nose, its banks of oars, and its terminal rudder. Under the same pressure the clumsy, lumpy, many-celled body, with its oars (cilia) distributed all over it, with no special head or mouth, evolved into an elongated body, with oars confined to its flanks, with pointed head and the more sensitive cells clustering therein, with outlet for its ejecta behind, and with, eventually, a rudder or tail.

This is the order of development indicated both in embryology and zoology, as well as the most natural order to assume, but our interest in it is confined to one set of organs. Of the general build it need only be said that there are reasons for believing that the hollow globular animal doubled in on itself, as one may press one half of an india-rubber ball in upon the other, The change may have been due to a growing habit of feeding at one spot on the surface, where the cells specialised on digestion. When the process was complete, the inner layer of cells served for digestion and generation, the outer layer were released for locomotion and sensitiveness alone. Such animals are found in nature. The Cœlenterate, indeed, is substantially of that type, somewhat modified to suit its generally sessile life.

In a free-swimming animal of this structure an important modification would inevitably occur. Such an animal would travel mouth first, and, amongst other changes, the sensitive or nerve-cells would gather at the head. To put it more accurately, those animals in which the sensitive cells were most strongly developed in the head region, where they were most useful, would have an advantage in the struggle. Sensitive cells at other parts of the surface would tend to disappear. Those animals, again, in which the cells became more effective by specialising on certain stimuli (light, odour, &c.), or forming into sensory groups, would have an even greater advantage. The next great step would be when a central cluster of nerve-cells was connected with the various sensory spots by lines of cells (nerves), and could combine the partial impressions they received. In other words, we should expect the next definite type of organism to be an elongated worm-like body, with mouth at the anterior end, and a group of rudimentary sense-spots, communicating with a rudimentary brain in the region of, or above, the mouth.

We find all stages of this theoretical process so fairly illustrated in the worm-group that we regard it with some confidence as the line of development. But the shores of the Cambrian ocean, or the rocks which now represent them, show that a great variety of animals, besides the worms which burrowed in their mud, already existed. We find shells of Molluscs, fragments of Echinoderms, and shreds of the tough coats of Crustaceans. All these groups were therefore developed before the proper archives of paleontology open, and we must see how far "mind" is developed in them. They are only represented in very primitive forms, but it will be necessary to run over the four groups, as we have them to-day, to see how far they have evolved "psychic" power.

We may take first the large and varied group of Worms, or worm-like organisms which used to be comprised under that title. To describe fully the neuro-muscular mechanisms and the habits of the many groups in this vast kingdom would require a volume. We must be content to examine a few typical groups, and discuss what are thought to be the nearest approach to mental processes in the higher orders.

The lowest position of the group is occupied by the flat worms (*Platyhelminthes*), in which we see the gradual development of the perceptive mechanism. The simplest of all are the tiny freshwater Planarians, which have, in varying degrees, the rudimentary brain—a simple cluster of nerve-cells—and the rudimentary sense-spots, such as I have described them. The eye (or ocellus) is a cell containing pigment-granules, with retinal cells behind it, from which an optic nerve proceeds to the brain. In higher Planarians the ocelli are accompanied with sensitive cilia and tentacles, otocysts (granules on sensitive beds, which were thought to be rude organs of hearing, but are now generally regarded as organs for the sense of direction, and called statocysts), and other clusters of sensitive cells. As we pass the successive groups of Worms in review these sense-organs become more efficient, and the brain (or ganglion) larger. The mechanism for receiving, associating, and transmitting impressions is gradually improved, and we shall expect a more serviceable response to stimuli. Do we find anything which disposes us to pass beyond the working of this admirable mechanism, and suspect the presence of feeling, will, or other conscious state?

Loeb has made many experiments on the Planarians, which seem to show, not only the absence of consciousness, but the curious responsiveness of the body even apart from nerve. He found that a Planarian (*Thysanozoon*) righted itself when put on its back. If there be any consciousness in these lowly organisms, it will be, as in the higher, associated with the brain. Loeb cut out the animal's brain, and it righted itself, when turned over, but more slowly. The Planarian moves quickly because its motile cilia act in accord all over the body. Loeb cut one across the body, severing the nerves, but leaving a muscular link. The latter half of the body still acted in almost complete accord with the anterior half. He found certain Planarians (*P. torva*) very sensitive to light, cut off their heads, and put them on a dish half covered with black paper. Both heads and body-halves made their way out of the light.

Planaria torva is one of those animals which can reproduce the removed head. Loeb found that it could, on suitable incision, grow additional heads—Dr. van Duyne provoked one to form six heads—and that, if you induce the second head at a sufficient distance from the first, the two will pull in different directions, and may tear the body asunder. This power of reproducing a head with brain and fairly developed eyes is no more connected with consciousness than is the building of the embryo, yet it is one of the most wonderful things about the worm-mechanism. The whole of the experiments point to unconscious action, and nothing has been claimed in the life of the Planarians that shows more than a mechanical response to stimuli received.*

In the succeeding orders of the Turbellaria (the lowest flat-worms) we have only to note slight advances in the neural mechanism, but when we pass on to the next classes of the Platyhelminthes, the Trematoda, and Cestoda, we find some very instructive features. Both groups are parasitic. The lower worms tend much to taking shelter in the cavity of a larger body, and this probably led to the fixed parasitism of the "flukes" and "tape-worms." Of consciousness there can hardly be question, as the brain has degenerated. The supreme interest of the group is in the remarkable adaptations and habits which so well exhibit the capabilities of unconsciously evolved and inherited nervous mechanisms.

The clinging and suctorial apparatus, the hooks and suckers of the tape-worm, for instance, are so well known that they need only be mentioned. More remarkable is the habit of the Trematoda of finding

* See Loeb, *op. cit.* p. 82.

an intermediate host in which to develop their young. Take the liver-fluke (*Distomum hepaticum*). This worm lives in the gall-duct of the sheep, where it gives off innumerable eggs. These pass into the gut and are ejected with the excrements. If they chance to enter a pond, the young worms develop and bore into the body of a water-snail. Some of them then pass into a second host (only to reach sexual maturity if the animal is eaten), and others enter the water-plants, and enclose themselves in capsules in the tissues. If the sheep eats the plant, the worms burst the capsule in its intestine, and pass on to the liver. Another *Distomum*, a parasite on the bird, develops in tubes inside the snail. The tubes are green, with white bands, and when they burst from the snail's body, they wriggle about on the ground. The bird, thinking it a caterpillar, swallows the brood of its enemies.

This story of worm-parasitism is endless, but the two illustrations must suffice. Here is a marvellous adjustment to conditions of life—the millions of ova, the capsules, and the intermediate host—for which a "dim consciousness" would not be of the slightest service. Like the skeleton of the Radiolarian, or the division of labour among the Siphonophores, it is a striking simulation of intelligence, yet a palpably unconscious process. The generation of parasites would perish with their hosts if their eggs developed inside the bodies on which they prey. An extraordinary mechanism has been evolved in their organisation by which, on repeated stimuli from their surroundings, they find their tortuous way back to the host. Such processes must restrain us when we are disposed to doubt the capabilities of neuro-muscular apparatus apart from consciousness.

In the succeeding classes of the Nemertinea and Nematoda we find a continued advance of the perceptive apparatus. The eye obtains a refractive medium, or lens; the brain is formed of two masses of nerve-cells, with connecting commissure, or ring of nerve-matter. As the most remarkable activities attributed to them are parasitic feats, such as those already described, we need not linger. We have to consider claims of mental quality in a few other higher animals, which are vaguely included in the vast worm-group—earth-worms, leeches, tube-dwellers, and rotifers.

The earth-worm, an advanced type with a pair of connected cerebral ganglia, has had many supporters since Darwin bestowed so much attention on it. It seemed to Darwin that, as they dragged leaves of different shapes into their burrows, they showed some intelligence in adapting the method of drawing to the size and shape of the leaf. Principal Lloyd Morgan observes that such judgment seems beyond the lowly organisation of the earth-worm, and most writers will agree with him. It is, he thinks, a different reaction on a different stimulus, due to an inherited mechanism. However, when he comes to consider the closing of the burrow, he is disposed to think that they " learn by experience,"

and for him this is a test of the "presence of mind.*
The variation, like the alteration of method in drawing the leaves, does not seem to require other explanation than the change of stimulus.

On the other hand, we must set against these questionable performances a number of observations which prevent us from attributing a special psychic importance to the large double ganglion, or brain, of the earthworm. The nerve-matter is disposed in a double chord along the body, and this swells to a bulb (ganglion) in each segment of the body. At the anterior end the nerve-matter is gathered in two large ganglia, united by a commissure, and connected with the sensory areas. If there is any shade of consciousness in the earth-worm, it must be associated with this brain, but experiment seems to show that this is not the case. Professor Loeb and Professor Whitman both concluded from experiment that the large anterior ganglia are not of a higher order than the others. A worm in which the chain of ganglia has been cut does not lose the co-ordination of its movements. A decapitated worm is still sensitive to gravitation and light. When a worm is cut in halves, it is the brainless half which wriggles, as if in pain (which it cannot be), while the brain-half does not; a fact which we must carefully remember in studying signs of "emotion" in animals.

In fine, the recuperative power of the earth-worm, which cannot be connected with consciousness, reveals a mechanism quite as remarkable as that of

* "Animal Behaviour," p. 159.

its cerebral ganglia. The two halves of a cut worm will often both generate the missing parts. Quite commonly the tail-end is renewed, though its anatomy includes an elaborate arrangement of nephridia, blood-vessels, nerves, and muscle. Occasionally the tail-half reproduces the head, with its brain and sense-organs. The aquatic relative (*Lumbriculus*) of the earth-worm has even greater recuperative power. One was cut into fourteen pieces, and no less than thirteen of the fragments grew into complete worms.* The worm is so liable to be nipped by enemies that the species might have perished if this curious defensive apparatus had not been evolved. But the hereditary mechanism, by means of which *Lumbricus* and *Lumbriculus* achieve this result is not less wonderful than their neuro-muscular mechanism.

In the related higher group of worms, the Hirudinea (leeches), there is only one observation on which a psychic interpretation may plausibly be put. Professor Whitman found that when a leech was made to face a presumably hostile approach, its behaviour was modified according to the presence or absence of eggs. Lloyd Morgan remarks † that this may be due to "instinct" but that we cannot say with certainty that it does not imply a dim intelligence. It is quite enough to recognise, as most students will recognise, that it *may* be instinct.

* Günther's "Darwinism, and the Problems of Life," (1906) p. 267.

† "Animal Behaviour," p. 160.

What we are seeking is a clear or probable proof of some activity in the lower animal which we cannot attribute to its neural mechanism. The fact that the leech reacts differently, according as it has or has not eggs, is not such a proof. The eggs form a distinct stimulus to action.

Nor do we find any such proof in the two other groups of worm-organisms which have an interest for us. The Polychæta, traces of which go back to Silurian times, are advanced worms with dorsal brain and double (or fused) chain along the body. Their four eyes have a simple lens and retina, and they have sensitive tentacles and palpi. Their most interesting habit is that many of them form and inhabit tubes. We have every degree of tube-formation within the class, and could draw up a fair scheme of the evolution of the habit, beginning with a group which simply burrows. Loeb's ingenious experiments show that this "instinct" of burrowing is probably an enhanced sensitiveness to gravitation (geotropism),* and he has proved that the animal's "instinct" may be entirely satisfied in circumstances where there is no concealment at all, so that even the dimmest intelligence is excluded.

Other writers point out that the tube-dwelling Polychæta show much faculty of choice in selecting the material with which to build the tube.† We

* In order not to mislead I must observe that Loeb by no means admits the evolution of these mechanisms by natural selection. We shall see his theory later.

† See "Cambridge Natural History," vol. ii. for details.

have seen that the "power of choice" is a very ambiguous test of psychic action. Not only is "choice" one of the essential phenomena of chemistry, not only does unconscious nature "choose" by the simple fact of killing off the less fit, but a complex nervous mechanism is expressly designed to discriminate between stimuli. Some of the tubes of the Polychæta are protectively coloured, some are phosphorescent, some are built in useful association (commensalism) with a different type of animal, which renders a return service for the concealment given to it. No one would credit a "dim consciousness" with these achievements. They are unconscious adaptations; and, as every such adaptation means the formation of some subtle nervous mechanism, which is transmitted from generation to generation, it is hardly logical to say that similar mechanisms may not account for any other feature of tube-making. In point of fact, the material for a protectively coloured or a phosphorescent tube must be "chosen," yet it would need a very acute consciousness, and in some cases a knowledge of chemistry, to make the choice deliberate.

As tube-formation is the only feature in the Rotifer group which needs special reference, we need not delay. The Rotifers, which some (as Professor Hartog and Professor Shipley) relate with the flat-worms, and others regard as a distinctly evolved group, are remarkable for the crowns of cilia round the mouth, which look like circling wheels, and make them attractive to the microscopist. One of them (by no means rare—I have found a London pond swarming with it) forms a remarkable tower out of the particles floating in the water, in which, based on the leaf of a water-plant, it takes its abode.

The action of the tiny *Melicerta* (a microscopic worm) in thus building its home, brick by brick, is extremely interesting, but it is precisely one of those facts which best show the capabilities of inherited mechanisms, and warn us not readily to introduce consciousness. Of such construction, in the conscious sense, even man was incapable until the Neolithic period. No psychic quality less than an advanced intelligence would help in explaining it. The rudimentary ganglion of the Rotifer excludes any such supposition. We saw that even Protozoa sometimes build houses, in the sense that, on contact, they exude a sticky plasm, to which grains of matter adhere. Probably the practice of *Melicerta* began with the showering down, by the wheel-apparatus, of grains of matter upon the sticky coat of the Rotifer. Other Rotifers secrete their tubes from the body. Consciousness of so low an order cannot be a factor in either case. They remind us rather of the purposive activity of invisible nervous mechanisms. We have, therefore, no clear indication of any activity of other than mechanical order in the vast kingdom of worm-like animals, and we must pass on to consider the other great groups of Invertebrates. From some early type of worm, or—it does not concern us to investigate the point—from some common ancestor with the worm, were developed the ancestral lines of the Molluscs, Echinoderms, and Crustacea. When the paleontological story opens, these groups are found to have primitive representatives in the Cambrian ocean. The spider and insect come later, and need fuller study. Bearing in mind that the higher types of the Molluscs, Echinoderms, and Crustacea also appear much later in the story of the earth, we may nevertheless take the groups as we find them to-day, and inquire whether there is in them any indication of other than neuro-muscular activity.

The Molluscs are dismissed by some students, like Professor Loeb, with a disdainful negative, and we may be dispensed from roaming over this broad kingdom of the shell-fish. The worm-like ancestor which obtained a protective coat of shell relieved its descendants from much of the exacting struggle for survival, and in the thicker-shelled specimens the brains and sense-organs have degenerated. Later, however, some branches of the family (snails, cuttle-fishes, &c.) threw off the incumbrance, and it is in these that some writers find traces of mentality.

Romanes, however, and Principal Lloyd Morgan make a claim on behalf of so lowly a Mollusc as the limpet. The limpet has unquestionably the power of recovering its original position on the rock after removal to a short distance. Of 25 limpets which Lloyd Morgan removed to a distance of six inches, 21 returned to the original seat in two tides; of 21 removed a distance of 18 inches, ten returned in six tides. But we have here only the lowly beginning of a power that reaches a great height in more advanced animals, yet even there is quite apart from intelligence. The bee probably orientates itself by sight, the dog by smell, but there is abundant evidence of homing (turtles, horses, asses, cats, &c.) in which no recognisable sense is detected, and even the acutest intelligence would be usless. Probably no one to-day would, with Romanes, grant the limpet a "mental image" of its home (which would not help it to cross an unknown route), and it is difficult to see that even a dim consciousness is either helpful or needful. There is clearly some nervous mechanism at work in the homing of animals which we have not yet detected.

That the snail, with its finer organs of sense, should exhibit the same capacity is more intelligible. It is not nearly so remarkable as the protective colour and shape of some of the naked-gilled snails, which have no connection with consciousness. But I may call attention to an even more curious habit of a lowly mollusc, which cannot be related to any conscious state. It is one of those purposive neuro-muscular arrangements which writers on animal life do not sufficiently appreciate, when they are restricting the range of mechanism in order to introduce mind.

The "painter's-gaper" (*Uniopictorum*) is made the receptacle of the eggs of a certain fish (*Rhodeus*), but, as Professor Günther puts it, it "has its revenge for the reluctant shelter." When the young molluscs develop at the bottom of the water, they send out long threads, which unite with those of their brothers to form a strong net. Into this net the fish, commonly a Rhodeus, runs, and the tiny mussels at once settle on it with the edges of their shells. A fold of the fish's skin gradually closes over them, and they quietly feed on their host's flesh until they reach maturity, when they break away.

The prince of the Mollusc world, however, is the octopus, and for this animal even a certain degree of intelligence has been claimed. The octopus affords an admirable illustration of the great psychic importance of mobility. Not only has it discarded the heavy deforming shell-coat of its Mollusc cousins, but it has turned carnivore, and developed great speed in pursuing its prey or avoiding capture. A shoal of octopi have been seen to leap from the water on to the deck of a vessel. We shall, therefore, expect an advanced evolution of the nervous system in the octopus, and are not surprised to find that, whereas even the snail has most imperfect vision, and is led chiefly by smell, the octopus has a finely developed eye, and its nervous ganglia are concentrated into more effective centres. This higher development of its neuro-muscular apparatus is in strict accord with the principle we have recognised, and the behaviour of the animal will be proportionately more effective.

We have to consider three claims for some shade of consciousness in the octopus. The first is a suggestion (" Camb. Nat. Hist." iii.) that its varying colours point to changes of emotion. The diagnosis of symptoms of emotion in the lower animals is extremely difficult. If we take at their superficial value the indications of anger, for instance, in an octopus or a crab, we shall come to the preposterous conclusion that this state of consciousness is as fully developed in them as in man. On the other hand, we have seen, and shall see again, that there are apparent signs of emotion in animals where there is no consciousness at all. In the case of the octopus the question is further complicated from the fact that its colour is "undoubtedly protective" (*op. cit.*) and varies with its environment. Deep emotion is in ourselves accompanied by violent nerve-storms; if not, as some think, the result of such storms. Such a nerve-storm would suffice to give these "signs of emotion" in the lower animals, and we have no safe ground to believe that the animal is conscious of them. Analogy is an excellent guide, when we pay it full regard. The signs of emotion in an animal may be analogous to those in man; but, to complete or modify the analogy, we must compare its brain with that of man.

On the mental side we have to consider an observation in which a young octopus was seen to approach a hermit crab, whose shell was guarded, as is often the case, by an anemone. The octopus was stung, and was seen to avoid such encounters afterwards, while older octopi were observed to extract the crab without touching the anemone. Principal Lloyd Morgan says that we have here a case of "profiting by experience through the exercise of intelligence."

It seems to me that the incident is well suited to expose the fallacy of "profiting by experience" as a test of intelligence. Assuming that by "intelligence" is meant a conscious process, we are not justified in deducing its presence from such behaviour. The concentration of ganglia in the higher animals, which is conspicuous in the octopus, suggests that an apparatus has now arisen for retaining and associating impressions, or such traces as they undoubtedly leave in the nervous system. That there is such a nervous apparatus in us, underlying our states of consciousness, no one doubts, and we may justly regard the concentration of ganglia in the higher Invertebrates as the first step in the evolution of the mechanism.

Such a mechanism suffices to explain the behaviour of the young octopus and most of these cases of "learning by experience." One has only to suppose that, in the complicated nerve-centre of the octopus, the sight of a crab-anemone group is henceforward associated with the organic impression of an injurious and repelling stimulus, and the theory of intelligence is quite superfluous. Learning by experience is the formation of a new association. There is no ground for assuming that, as yet, this process has a conscious side. If we consult analogy we should say that the complete absence of a cerebrum in the octopus makes it strongly improbable. In any case, the nervous machinery is of itself sufficient to provide an inhibition of a former action through a new association.

As to the fact that older octopi could extract the crab without touching the anemone, the explanation is comparatively simple. Repeated experience would complete the new association. In its various approaches to the succulent morsel, the octopus would occasionally touch it below the level of the anemone's arms, and receive no sting. I do not suppose any one imagines that the octopus deliberately calculates, as a trained angler might do, at what level it must act. Its success is the result of a slow process of selection. The more serviceable modes of behaviour, in which an impression of food-without-sting is associated with an approach on the level of the ground, would automatically gain on the more injurious impulses.

I have analysed this instance at some length because for some time now we shall find "learning by experience" to be the ordinary test of consciousness, and I submit that it is fallacious. The third claim for intelligence in the octopus comes from a lady (Jeannette Power, *Ann. Mag. Nat. Hist.* xx. p. 366) who observed an octopus lying in an aquarium, with a stone in one of its arms, beside a shell-fish of the oyster type. When the oyster was fully opened, the octopus quickly inserted the stone, and devoured the mollusc. On this isolated observation one must decline to build. Like the tower-building of the rotifer, it implies a very high degree of intelligence or none at all. Dim intelligence would not explain such an adjustment of means to end; and if there were in the animal such a degree of intelligence as this action superficially suggests, it could not possibly have escaped further observation. Indeed we have ample evidence of the unintelligence of the octopus. If further observation should discover anything like a stone-inserting habit among octopi, the episode will have a more satisfactory explanation than this assumption of a high intelligence manifesting itself in one single indication. At present we must conclude that even the highest of the Molluscs show no indisputable sign of conscious faculty and we may pass on to the next province in the invertebrate kingdom.

The Echinoderms form a group of great interest from the evolutionary point of view. The flower-like arrangement of the arms points to an early stalked ancestor, and the Cystoids, Crinoids (sea-lilies), and Blastoids show the retention of the sessile habit. One branch, however, abandoned the sedentary habit, flattened out, and evolved into the star-fish—an animal-flower detached from the stalk. The brittle-star seems to be an exaggeration of the star-fish; the sea-urchin and the sea-cucumber (Holothurian) are descendants of some primitive star-fish, appropriately modified (or rolled up) for the habit of pressing into narrow crevices. It is, on the principle we have discussed, to these active members of the group that we look for indications of higher nervous development.

The normal sensitiveness of the star-fish is not remarkable, as it is well supplied with nerve. A ring of nervous matter round the central part gives off rays to each arm, which eventually descend in branchlets to the innumerable tubular feet, each of which has a special cluster of sensitive cells. There are also "eyes," or sensitive pigment-lined cups in the ectoderm. Its quick response to stimulation by light or touch is not, therefore, remarkable. Nor can any mystic element be detected in the power which the star-fish has of recovering, if it is laid on its back. Experiment has shown that the absence of contact causes the tube-feet to move restlessly until they touch a solid. It is not necessary that the solid be the ground. As to the co-ordination by which three arms find the ground, while two remain at rest, and so allow a pull in one definite direction, it is usually believed that the central nerve-ring controls the process. Professor Loeb, who always depreciates the central system, denies this. He insists that the ring merely conveys a stimulus, and that, through it, the three arms inhibit the other two. It it important to recollect that—as I have verified—a single arm, detached from the body, will succeed in turning over.

If we feel any difficulty in conceiving that the star-fish could evolve a mechanism for regulating the struggle of its arms when overturned, we must remember that it has evolved a much more remarkable mechanism. This gives it the power to reproduce an arm, with all its wonderful arrangement of tube-feet (one of the most curious locomotive structures in the whole animal world), when one has been lost. But we may at once consider the most notable observation in support of the assumed intelligence of the star-fish.

Professor W. Preyer made a series of minute experiments on the star-fish which gives us one of the most instructive studies we have of the neuro-muscular activity of the lower Invertebrates.* The normal movements he sets down at once as due to reflex (unconscious) nervous action. He then tried a series of experiments by suspending them from corks. These experiments Professor Loeb has controlled, and come to a different conclusion; but the difference between the two physiologists is on a point not involving consciousness. Preyer eventually made an experiment on a brittle-star, the result of which seems to him to reveal some shade of mental action. He repeatedly put a rubber band on the animal's arm, and watched the varying efforts to throw it off. At first the animal tried to rub off the tube on the ground. If this failed, it waved the arm about in the water. When this did not succeed, the animal pressed the loaded arm to the ground with another, and tried to rub the band off; or tried to push off the band with the next two arms. When all these measures failed, it broke off the arm (as the brittle-star often does, since it has a high power of regenerating).

Here, again, the attempt to introduce a mystic

* "Uber die Bewegungen der Seesterne," *Mittheilungen aus der Zoologischen Station zu Neapel*, Bd. 7.

element seems to be both superfluous and useless. Dim consciousness does not help us. If we interpret the action in terms of consciousness, it seems to involve an act of reasoning worthy of an advanced mammal. On the other hand, since the arms of the brittle-star are so constantly endangered and entangled, it is not unnatural that it should have many ways of reacting on the stimulus of entanglement, which would itself greatly vary. In fine, since we must recognise a mechanism in the brittle-star capable of regenerating unconsciously the intricate structure of its arm, it is not much to admit a less wonderful mechanism for adjusting its behaviour to conditions.

Professor MacBride, commenting on Preyer's experiment, declines to see any mark of intelligence, and refers us to other experiments made at Naples on the allied sea-urchin.* In these Professor Von Uexhüll submitted the sea-urchin to very severe tests, and concluded that its movements, which are closely analogous to those of the star-fish, were in all circumstances mechanical. He was forced to believe that the central nerve-ring has in no sense the value of a brain, and does not control the co-ordination of the animal's movements. As the central nerve-structure is essentially the same as in the star-fish, we need linger no further over the Echinoderms. Their organisation is so replete with mar-

* "Cambridge Natural History," vol. i. The reference to the Naples *Mittheilungen* is wrong, and I have not been able to trace Von Uexhüll's paper.

vellous mechanical adaptations, that we may justly look for even less remarkable mechanisms in their less easily investigated nervous system.*

The last and most interesting group of animals which we find in the Cambrian ocean is the Crustacea. This group, so familiar to-day in the shrimp, the crab, and the lobster, had an immense extension in the primitive waters. Starting, apparently, from some worm-like ancestor, they developed the articulated body and tough armour which distinguish the group, and branched into curious and gigantic forms. The Trilobites ploughed the mud of the ocean in search of their food, their compound eyes sometimes possessing no less than 15,000 facets. Eurypterids, sometimes six feet long, like giant scorpions (with which many authorities now classify them), were the dragons of the deep. Smaller Phyllopods form some link with modern forms of the group. The eye made a very notable advance of development in these animals, and we wonder if there was any evolution of mind amongst them.

Unfortunately, the more interesting forms of these ancient Crustacea became extinct at a very early date in the story of the earth. We have again to take the Crustacea group as we find it in nature to-day, and apply its features to the earlier representatives. The great majority may be ruled out

* A third group of the Echinoderms was closely studied by Dr. R. S. Semon. He found no trace of psychic activity in the Holothurians. "Beiträge zur Naturgeschichte der Synaptiden des Mittelmeers" (*Mittheilungen*, Bd. 7, p. 287).

of our inquiry at once, as no claim is made on behalf of the barnacle, water-flea, cyclops, sand-hopper, shrimp, wood-louse, or fish-louse. The crab is the only Crustacean that offers us any psychic interest. Mr. Headley applied to a number of crabs the test of seeing whether they would learn by experience.* The lesson consisted in dipping them in fresh water —an uncongenial process—as a penalty of nipping. A number of the crabs desisted from nipping, or relaxed as soon as they nipped, after repeated immersions. Mr. Headley concluded that they could learn by experience, and had some degree of mentality.

In examining this—the only claim I find of mental quality in the Crustacea—it is necessary to define rigorously what we conceive to be the result. Mr. Headley is one of those writers who believe that "if an Infusorian is but an implement played on by the environment, man must be set down equally as an instrument that is played upon." I have protested against this tendency to keep the human mind in view, and prepare the way for it, in studying the lowest animals. We have an automatic organisation as well as a sphere of consciousness; and, as we know that the latter is associated with an elaborate brain, it has no title to be dragged into comparison with an animal like the crab, which has so slender and crude a nerve-centre. The question to be answered is not, can we find any actions in a lower animal which are consistent with a theory of consciousness, but can we find any which are inconsis-

* "Life and Evolution," pp. 191–4.

tent with a purely neural action. The question of consciousness does not arise until then.

Now, the essence of Mr. Headley's observation is that—setting aside the matter of fatigue—the crab comes in time to have a fresh impulse, or registration of a stimulation, associated with its impulse to nip. The preserved impression of the bath is associated with the impulse to nip, and the usual prompt direction of the nipping muscles is suspended, or weakened. Not only does this seem quite within the range of a neural mechanism, but certain experiments related by Professor Loeb show that it is. It was found that *Limulus* (the "king-crab") still distinguished food from pebbles after its chief (or supraœsophageal) ganglion had been removed. The "selection" between digestible and indigestible matter was a purely mechanical response to appropriate chemical or visual stimuli. "Learning by experience" may be just as mechanical as "choice." It means, in essence, that a new association is formed, which complicates the earlier normal sequence of impression and response. Now, whether we admit consciousness or not, this new association is primarily in the nervous system, and in this case there seems no reason to go further.

I conclude then, that in the invertebrate world, apart from the spider and the insect, which appear much later, and will be considered separately, no instance has yet been found of any other than neuro-muscular activity. We may choose to speak of that activity as, in one aspect, "psychic"; we may care to give the name of "mind" to the totality of their nervous reactions. But most of the recent physiological experts are agreed that those reactions are automatic. If Preyer is, to some extent, an exception, we must remember that Preyer has a singular theory of the extension of life throughout inorganic nature, and his language needs special interpretation.

But, apart from the question of authority, I have covered the whole ground with great care, so as to secure a firm base for the next and more difficult stage of our inquiry. The Protozoa and the Cœlenterates may be summarily dismissed. In the succeeding worlds of the Worms, Molluscs, Echinoderms, and Crustacea few and slender claims are made for the presence of an agency other than that of their nervous mechanism. The general reader is so accustomed to associate life and mind that the conclusion may appear strange, but this survey of the whole literature of the subject has discovered only a few very unsubstantial indications of mind—as distinct from nerve—in the broad invertebrate kingdom. What we do unquestionably find is a nervous mechanism, and other mechanisms, of most intricate, unexplored structure and remarkable capabilities. I have been able to give only a few out of the myriads of remarkable processes that we must dissociate emphatically from consciousness, and attribute to the automatic mechanism. This mechanism, we saw, can perform actions far more complex and purposive than the few processes in which some would detect consciousness.

It is admitted, in fact, that complexity or purposiveness in a reaction is no test whatever of the possession of mind. The serious, scientific claim is that in a few instances an animal was seen to adjust its behaviour to its surroundings in virtue of its personal experience, not of its inherited mechanism. I postpone the full analysis of this test of intelligence until we have to deal with the more impressive activities of the higher insect. For the moment I submit only—and do not see how it can be questioned—that the formation of a new, restraining (or inhibiting) association is a neural as well as a conscious process, and may be quite effective without consciousness. This would be a sufficient explanation of the chief instances we have examined. I do not say there was no consciousness in the acts, but that we are not forced to recognise it as yet. And when we reflect further that in most of these half-dozen cases the assumption of a dim shade of consciousness is not of the least assistance, while we certainly cannot admit a more advanced faculty; that scores of experiments show remarkable capabilities in these animals even after the removal of the brain, with which such a dim consciousness would be associated; and that time after time we find obviously unconscious agencies doing what would seem to require an advanced intelligence, we may resign ourselves to regard this invertebrate kingdom as a realm of neuro-muscular mechanisms, and probably nothing more.

CHAPTER V

THE DEVELOPMENT OF THE FISH

INSTEAD of proceeding at once to deal with the last and highest division of the Invertebrates, I propose to turn aside and examine the activities of the fish. The reason for this somewhat unusual order is that I have chosen to retrace the line of cosmic development rather than to follow the divisions of the zoological world. It is more profitable, in this inquiry into the cosmic unfolding of mind, to describe and analyse the story of life-development in the order in which it occurred. The first chapter was a period of lowly unicellular life. The second brought before us an epoch of primitive multicellular animals, from which we dimly trace the emergence of the various invertebrate groups we have already considered.

The next phase of importance in the story of the earth is the transfer of the organic struggle from the ocean to the land. The continental surfaces are rising above the level of the water, and swarms of living things crowd about their shores. Many of the animals and plants escape from the increasing struggle in the ocean by becoming adapted to live on land and breathe the air. It is on the land, under entirely new and more stimulating conditions that the higher Invertebrates (spiders and insects) will be evolved. This marks a new and most important stage in the planet's development, and it will be best to complete the first part of the story before we approach it. So far as the invertebrate world is concerned, we have as yet found no type of life which clearly exhibits any other than neuro-muscular activity. Whether we shall find a different type in or after the dense semi-tropical forests of the Coal-period, we have yet to see. But the fish had been evolving for millions of years before the Coal-forests, and it claims our attention before we pass to the higher level of life on land.

As we now approach a group of animals in which mind, in an undefined sense, is generally recognised, I must state more clearly the terms of the inquiry. The only serious divergence from the conclusion so far is the view of those who (like Principal Lloyd Morgan) regard mind as another "aspect" of the activity of an organism, not as a separate reality. They believe that mind may "accompany" without active intervention the working of the neural machinery I have so far described, in the more complex cases.

This view must be considered presently, but it should be quite clear that what I am chiefly seeking to determine is whether a new reality, or agency, besides ether, intervenes at some point in the earth's story. It is generally acknowledged that the early phases of the planet's story exhibit solely the evolution of ether. The chemical elements, which make up the mass of the planet, come from the ether; the plasm of living things comes from the chemical elements; and the neural mechanisms, which accomplish such purposive reactions in the organism, are composed of a special form of plasm. "Force" and "energy" I leave out of account, for the reason given previously. To say that electricity, &c., enter into the play of the neural machinery is only another way of saying that they are etheric constructions. The plain purpose I have in view is to see whether, and when, a new reality, other than ether and its products or aspects, enters into the tissue of our planetary life.

In strict accord with scientific procedure, we must say that the only decisive proof of the appearance of such a fresh reality will be a proof that the behaviour of some animal is plainly, or probably, beyond the possible range of an elaborate neural mechanism. My point is, therefore, not so much whether we find consciousness in an animal, though to this we naturally attend, as whether the animal's actions demand in any case a substantial substratum, or agency, or reality, other than its nervous system. When we have plain evidence of the appearance of consciousness, we shall, of course, have to consider whether this itself does not point to a non-neural substratum. But it is important to recognise the two different questions. On the other hand, it is not as yet important to attempt to define consciousness, if such a feat can be accomplished. Simply, we have to inquire whether the neuro-muscular machinery of the fish may or may not be held adequate to account for its activities.

The paleontologist finds the first fragments of fishes in the lower Silurian, or the Ordovician, rocks, and so is inclined to put their first development in the Cambrian. An American writer has plausibly suggested that life began in the deep waters of the ocean, and that, as the animals came later to touch bottom on the shores of the rising continents, they developed hard skeletons (internal or external) for the support of their soft frames. However that may be, we do find the debris of an invertebrate shore-life in the Cambrian deposits. Presently we begin to find fragments of animals with internal skeletons—frameworks of cartilage, tending to harden into bone—and we recognise the early fore-runners of the vast fish group. Whether they developed directly from a worm-like ancestor, or came through a Crustacean ancestor, is not at present agreed.

The theory that the fish developed from a Crustacean ancestor, though not generally accepted, is of some interest from our point of view. Dr. Gaskell * has urged it for many years, and recently given us a finished presentation of it. Some of the earliest fish-like forms to appear in the strata (*Cephalaspis*, *Pteraspis*, &c.) have no jaws and no vertebræ, and it is claimed that they probably descended from the large primitive Crustacea, to which I have referred. The interest of the theory

* "The Origin of Vertebrates," 1908.

for us is in its account of the origin of the vertebrate brain and spinal cord. The large nerve-mass or ganglion in the head of the Crustacean seems to be the outcome of the fusion of many smaller ganglia of the worm-like ancestor. As the anterior segments of the worm-body are modified into the appendages of the Crustacean's head, their ganglia fuse into an increasing mass above and below the gullet.

Dr. Gaskell contends that this growth of nerve-matter (or brain) round the gullet would lead to a crisis. The more the brain grew, the more it would narrow the alimentary tube, and the animal organism would be faced with the alternative of sacrificing brain-growth or gullet. The spiders and scorpions met the crisis by taking to sucking blood, which allowed a great narrowing of the tube, but the ancestor of the fish met it by developing an entirely new alimentary canal. The growing nerve-matter then occupied the old tube and stomach, so that the ventricles of the brain would now represent the deserted cephalic stomach, and the spinal canal the deserted alimentary tube, of the invertebrate ancestor.

This theory, however, of which very curious and interesting proofs are offered, is not as yet widely received. Most authorities believe that the fish came directly from a worm-like ancestor. There are worms, such as the "acorn-headed" worm (*Balanoglossus*), which have gill-slits for breathing and a trace of a notochord—the dorsal rod of cartilage which precedes the backbone. The fins are believed to be due to the formation of folds in the skin of the wriggling animal, which would be strengthened by rods of cartilage and form paddles.

However that may be, the earliest undisputed fishes in the fossil records are shark-like organisms, which abounded in the later Silurian ocean. The Elasmobranchs (sharks, rays, &c.) of to-day are the lowest of the true fishes in point of organisation, and are generally regarded as the ancestral type. In the next (Devonian) period, however, other types have evolved, and the earth passes into the great age of fishes. Sharks of prodigious size and varied structure abound, and with them are fishes with plated coats (Ganoids), and fishes with lungs as well as gills (Dipnoans). These groups dwindle in later ages and give place to the bony-framed fishes (Teleosts), to which most of our familiar types belong. For our inquiry into the development of mind we may safely take the life of modern fishes. The petrified skulls of the older types show a less advanced brain than in the fishes of to-day, and, if we do not find mind in the latter, we may dismiss the entire group.

We have now to deal with a more massive and intricate nervous mechanism than hitherto, as the advanced organisation of the fish will imply. Compared with the cerebral ganglion that is believed—under protest from Professor Loeb and others—to discharge the function of a brain in the Invertebrate (as far as we have yet considered it), the brain of the shark is a large and complicated organ. In the lowly fish-like lamprey the brain is a small bulbous expansion, with little differentiation, at the end of the spinal cord. In the shark it is an expanded and highly differentiated organ. The embryonic development, in accord with the series we find in zoology, shows it to be at first an expansion of the anterior end of the spinal cord. It then differentiates into three main parts,* of which the first (the "fore brain") develops large olfactory lobes, optic thalami, and other parts. The hind brain develops a large cerebellum in the more advanced sharks, and is continued, through the medulla, in the spinal cord, from which nerves are given off to the body and limbs. A powerful olfactory organ (with double nostril) communicates directly with the fore brain, and the eyes are well developed. In addition, there is now for the first time a nerve-tract which seems to be a slender forerunner of the important cortex of the higher vertebrate.

The nervous mechanism has, therefore, made a great advance in the fish, but it will be advisable once more to glance at the theories of Professor Loeb before we build on it. For him nerve is merely conducting tissue. His colleague, Dr. Mathews, claims to have shown by experiment that nerve consists of highly phosphorised fats in a weak salty solution. The weaker the solution, the poorer

* In his "Nervous System of Vertebrates" (1907) Dr. Johnston says that the early neural tube was probably differentiated into four zones, concerned, severally, with somatic sensation, visceral sensation, somatic movement, and visceral movement. "Sensation" must, however, be taken in a broad sense, not as implying consciousness.

the action; for effective work the nerve should have a jelly-like consistency. And what the stimulus does, they tell us, is to cause in the nerve a rapid series of chemical precipitations, in which the negative charges of the atoms are released all along the line until the muscle is reached and stimulated.

On this theory the essential function of the nerve is to supply a series of ions, or atoms, charged with electricity, by which the stimulus may be telegraphed, as it were, to the pertinent muscle. Advance in nervous organisation consists in the provision of efficient paths from the sense-area to the muscle, and in the co-ordination of the responding muscles. But Dr. Loeb does not admit that the brain has a preponderant rôle in this co-ordination. It is a central bureau, or cluster of bureaux, for receiving and sending on the stimulations received at the sensitive areas (nose, eyes, skin, &c.). In addition to the many experiments already quoted. Loeb found that, when the brain was removed from a dead shark, it still responded, by closing the pupil, to the light-stimulus; and he found that defæcation takes place normally after removal of the spinal cord.

The remarkable results obtained by Dr. Loeb and his colleagues serve to illumine the mechanical nature of the organism, but it may be questioned if their policy of belittling the central nervous system has not been carried too far. Sooner or later an apparatus must arise for recording and associating the stimulations received. There is obviously such an apparatus in the higher Vertebrates, and the complex brain of the shark seems to exhibit the beginning of it, as Dr. Johnston points out. We are, in any case, dealing with a more advanced nervous mechanism, and may expect a corresponding improvement in adjustment to conditions.

Before we proceed to examine the life of the fish, however, we may again glance at some of the complicated processes we find in it quite apart from consciousness. The process of embryonic formation is, throughout the whole realm of the higher animals, the most striking and least noticed of such phenomena. Consciousness is out of the question in this bewildering complex of purposive reactions on stimuli, nor does the "vital principle" assumed by a few really give the slightest explanation. The vague "directive principle" introduced by Neo-vitalists, and regarded as unconscious, is not a whit more helpful. The embryonic development of the orchid or the sun-dew is little less remarkable than that of the animal, and, indeed, the extraordinary results obtained recently by experimental embryology put a distinct mechanical complexion on the whole process. Ova have been chemically fertilised without sperm; ova have been intoxicated so as to admit several spermatozoa instead of one; fragments have been made to develop small embryos, or half-embryos; and the whole course of development has been skilfully controlled by the use of mechanical and chemical agencies.* The whole trend of embryological work is to confirm the general view that the process is mechanical. That the mechanism somehow involved in the twenty-five billion molecules of an ovum (Professor M'Kendrick's calculation for the human ovum) is unknown, and its working, as yet untraceable, does not affect the issue. We have in the embryonic development an astoundingly complex result, far transcending the highest human art, attained by an unconscious mechanism.

Hardly less instructive are the many structures and devices which the fish has unconsciously evolved in the struggle to eat and to avoid being eaten. There are regions in the abysses of the ocean, where the rays of the sun never penetrate, which are lit up, as plainly as many a country village at night, by the phosphorescent organs of their living inhabitants.† Fishes glide along with a whole gleaming broadside of lamps, or suspend a single lamp by a special tentacle over the gaping mouth. In some of them the light is believed to be under control. In the production and arrangement of these luminous patches mind has had no share.

Other fishes can inflate their bodies when they

* See especially, Przibram's "Embryogeny" (1908.) The science of embryonic deformations, teratology, has the same tendency.

† Professor Verworn ("General Physiology," p. 255) attributes the light to an oxydation-process in the skin, not to phosphorus. This, of course,does not affect my point. See Bölsche's "Der Sieg des Lebens" for details.

are pursued, and cause a forest of spines to stand out, so that they are as little capable of being swallowed as a porcupine. Some have armed their tiny, but formidable, bayonets with deadly poison. Many have flattened out their bodies so as to lie close on the floor of the sea—the under eye traveling round the head—and taken on a protective colouring. The "angler" (*Lophius*) has developed a worm-like excrescence which he uses effectively as a bait. The little *Phyllopteryx* has adopted so weird a resemblance to the weeds among which it lives, that its feebleness is well protected. The *Rhodeus* pours its seed into a living mussel to develop. The "climbing perch" has developed a special bony chamber to supplement the action of its gills, so that it can walk over fields and roads in search of a fuller pool. The "mud fish" has evolved lungs as well as gills, so that it is adapted to either the dry or the rainy season.

With these, and a hundred other devices, in the life of a fish, consciousness is not concerned. They are so many illustrations of the capabilities of inherited mechanisms. In many cases the mechanism is quite invisible, nor can we tell how it arose; in some we cannot even trace its working. Yet mechanical these things undoubtedly are, and they must be borne in mind when we seek to put limits to the neural machinery of the fish's organisation.

And when we turn to examine the cases in which some higher than neural activity is claimed in the fish, we find that they do not lend themselves to any such interpretation. I have discoursed at some length on the intricacy of the nervous apparatus, and the very purposive results it attains without consciousness, because the general reader is apt to be startled at the suggestion that so advanced an animal as the fish may be no more than an automaton. An hour's careful observation of a few goldfish in a glass bowl, or of any group of fish in an aquarium, will convince him that there is nothing in their normal life inconsistent with such an assumption. Experiments on animals from which the brain has been removed give us a misleading impression of the behaviour of automata. We have eliminated consciousness, but we have also abstracted the most important part of the automaton.

The various efforts that have been made to detect mind in the fish suffer from the confusion of issues we have so often encountered. Let us take the questions in order. Firstly, have any reactions been observed in fishes which could not fairly be ascribed to the working of their neuro-muscular apparatus? Secondly, may or must we conclude that any shade of consciousness accompanies the working?

Romanes may be regarded as the advocate of canonisation in regard to intelligence in the lower animals. His work comes in the phase of thought when evolutionary science was beginning to react on the crude older notion that intelligence and consciousness were confined to man alone; and the reaction was excessive, as reactions are apt to be. The influence is not yet eliminated from the study of animal life. In the instance of the fish, however, Romanes made out a singularly poor case. He found memory in the fact that fish will repair year after year to the same spot for spawning; memory and a certain shade of intelligence in the fact that fish will learn to come up for food at a shout, a bell, or the approach of a keeper; and a certain intelligence in the practice of feigning death (perch, &c.) during pursuit. Brehm, another somewhat generous student, admits that fishes have very little understanding, but he finds some trace of it in their power of distinguishing enemies from friends and neutrals, their wariness after a time in avoiding traps, their choice of favourable localities for hunting and their care of the young. More recent writers rely chiefly on the fact that the fish can be tamed.

Most of these habits do not imply consciousness, and are not at all beyond the range of neural mechanism. Memory may be entirely physical. The obscure physiological processes which are in us the physical basis of memory may be in lower animals unaccompanied by consciousness, as I have indicated in the case of the octopus and the anemone. Feigning death is not an act of intelligence. Dr. Zell, a strong supporter of animal mind, declares that in "feigning death" there is no purpose of deceiving as to the animal's condition, but a mere instinct of inactivity, a suspenson, under strong stimulus, of all impulse to move. The power of distinguishing enemies and the care of the young would be generally admitted to have no concern with consciousness, but are due to an hereditary nervous mechanism.

Of the fact that fishes become warier in waters that are much fished, and avoid bait or traps, Mr. Hobhouse gives a plausible explanation. It may very well be a process of natural selection, by which the more impulsive are killed off and the more wary survive. There is no evidence of "learning." On the remaining fact that the fish can be tamed, and will at times come to its master for food, practically the whole case for fish-mind depends. There is no doubt whatever as to the fact. We can well believe the stories of the ancient Romans and their pet carp in view of modern experience. I have seen a photograph of a *Protopterus* walking on its fins to take bread from the hand of a keeper in an aquarium.

Here the current test of mind—to learn by experience, or modify instinctive behaviour on the ground of individual experience—seems to have a clear and successful application. Even Mr. Hobhouse, a careful student, grants the fish "a certain grade of intelligence." I find, however, that when Mr. Hobhouse comes to describe similar experiences with snakes and frogs, he admits that it is possible to explain them by assuming the unconscious formation of a new association, or a selective process among random movements of the animal; and that as the explanation is not clearly unsatisfactory, we are not justified in introducing intelligence.

This is precisely the explanation I have offered of previous cases in which mind was postulated, and it certainly does seem to cover the facts. That new associations can be formed in the nervous system—indeed, must be formed—can hardly be questioned, except by one who would think there may be mental processes in us without corresponding physical processes. Romanes himself holds that the function of the cerebral hemispheres is to deal with stimuli so varied that special reflex mechanisms have not yet been assigned to them.* There seems to be the beginning of such an associative centre in the shark. Unless, therefore, we are prepared to admit *unconscious* memory and *unconscious* intelligence we are not justified in ascribing these faculties to the fish. Virtually, the tamed fish has "learned by experience"; but that it has done so consciously we are not justified in asserting. The neural mechanism is capable of forming the new association which leads to modification of the inherited activity. Since that neural apparatus is not yet associated with such a structure as we know to be the organ of consciousness in the higher mammal, we should rather be disposed to think that it is not yet illumined by consciousness. We must conclude that there is no proof of conscious memory, perception, or reason in the fish.

The popular imagination infers intelligence from such habitual practices as that of the stickleback in making a nest, and guarding the eggs and the young

* "Mental Evolution in Animals," p. 74.

against its fellows. More serious observers have been accustomed to attribute these habits to that mysterious power called "instinct," which will be discussed in a later chapter. In the present stage of science it is usual to acknowledge that such practices, however complex and purposive, are not beyond the range of an inherited mechanism. That they depend on a nervous arrangement which is inherited, is obvious enough; and there is no more reason to regard such mechanism, as outside the range of unconscious selection, than there would be to regard in that light the quaint form of the *Phyllopteryx*, the electric apparatus of the *Torpedo*, the angling skin-lappet of *Lophius*, or the illuminative devices of the phosphorescent fishes.

If, however, we have no reason to see in the fish anything more than the play of its elaborate neuromuscular machinery, may we, or must we, at least recognise that states of consciousness arise out of, or accompany, its working? Frankly, the question cannot be answered with any degree of confidence. The passage of stimuli through the animal's nervous system may, in this connection, be likened to the passage of a current of electricity along a wire in which a filament of carbon has been interpolated, as in the lamp. Vision will detect the moment when the current reaches such an intensity as to raise the filament to red, and then to white, heat. A blind man may guess roughly from the heat radiated whether the carbon is incandescent or not, but he is quite unable to detect the first beginning of incandescence. In regard to the consciousness of other animals we are in the position of the blind man. In our own consciousness we know when the requisite intensity is reached; we can also declare with moral certainty that the filament is incandescent—that consciousness exists—in the bird and mammal; and we can be morally certain that the filament is not provided—that consciousness cannot be found—in certain animals of lowly organisation. But we cannot decide with the least approach to confidence when the new energy is first evolved.

There may be a dull glow of accompanying consciousness in the fish. That it cannot be more seems quite plain from the extreme poverty of the organ which anatomists regard as analogous to the human cerebrum. We are, in fact, in a serious dilemma. The aspect of the fish's life which most impressively urges us to ascribe consciousness is the emotional aspect. The anger and solicitude of the male stickleback as it guards the nest, the deadly struggles of rival males, the agitation of the sexual moment, have been often and vividly described. The difficulty is that the manifestation of "emotion" is *too* vivid. It is preposterous and incredible that the fish has states of consciousness as vivid as our own, yet this is what the behaviour of the animal seems to imply. The just inference from such behaviour is not at all so easy as some writers imagine. If I may revert to the figure of the electric lamp, we know that the resisting medium in the fish is of the crudest and least efficient character, yet we are asked to believe that it engenders an incandescence equal to that of a filament of tungsten.

We must again ask whether the non-conscious processes in ourselves do not afford us more guidance. No one will be likely to question that the external manifestations of emotion in man are due, not to the conscious states of feeling, but to the intense nerve-storms which underlie them. The effect on the heart and viscera is enough to guarantee this. In the lower animal, therefore, the external indications point directly only to the occurrence of similar nerve-disturbances. How far they are accompanied by consciousness depends on a totally different consideration. It depends on the structure of the specific organ of consciousness; and when we reflect that this is in the fish so meagre as to be only remotely analogous to the human cortex, it seems more scientific to assume that the "emotions" of the fish scarcely, if at all, rise to the level of consciousness.

There is no need to dwell on the many recorded instances of fish-stupidity. The alleged indications of conscious states are so equivocal and scanty, and the teaching of comparative anatomy so plain, that we are by no means yet compelled to pass beyond the nervous machinery to explain the source of activity. At the same time we must not be tempted to draw a rigid line. The evolutionary view of the world is quite opposed to such a tendency. There may be a glimmer of consciousness in the fish, or even in the octopus and the crab. In the fish, especially, where anatomists discover an "archipallium" which they regard as possibly analogous in a small way to the "pallium" (cortex) of the bird and mammal brain, it is not unlikely. Since, however, it is so disputable and unsubstantial, we may refrain from speculating on its origin until we come to firmer indications of consciousness. We have good ground to leave the fish entirely to the comparative anatomist, and trust that further progress in the elucidation of its nervous system will suffice to yield an explanation of its activities.

We must conclude, then, that the story of life on our planet had run through a good half of its long course by the time when the Devonian continents offered a new theatre for the advancing struggle, and that as yet no new element had entered into the story. All that we can find so far, with any degree of confidence, is the evolution of an intricate neuro-muscular system, by which the organism is enabled to adjust itself to its surroundings. At some date in the obscure remoteness of the Pre-Cambrian period the film of surface-matter is quickened into living plasm, and the plasm is divided into infinitesimal vital units. The overwhelming majority of the authorities who now study these minute creatures with the most powerful microscopes of our time, agree that they are protoplasmic mechanisms. We found no serious ground at all for recognising in them any other than the familiar elements and agencies into which the basic substance of our universe had passed.

Then the broad, mechanical principle of division of labour sets in. The diffused sensitiveness of the Protist concentrates at certain spots, just as certain other spots specialise on swallowing or locomotion, and thus a stronger stimulus is received and transmitted to the rest of the cell-body. When, later, the body is built up of many cells, there is more room for the operation of the principle. One set of cells especially develops contractility (muscle): another set sensitivity (nerve). It is the same process by which a third set of cells becomes exclusively digestive. The sensitive cells gather into clusters, to receive a concentrated stimulus; and the stimulus is still further intensified by the specialisation of one group of cells on the light stimulus, another on the stimulus of odour, and so on. Some cells gather in a central group, and others spread in lines for conducting the stimuli to it. We get a brain, which can receive and associate the impressions made by the outer world. The front part of this brain seems to be the large bureau for receiving the imprints made on the outer sensory areas; the hind part seems to be the region from which the stimuli pass on to the muscles; the middle part is, apparently, the area in which takes place the supremely important, but still very rudimentary, process of association. This last part is as yet minute. With its growth, under later influences which we shall see, there will be a remarkable development of nervous life. In man it will become the predominent, overshadowing structure.

To that later development, its causes and its significance, we will now proceed. A series of far-reaching changes in the conditions of life will prepare us for great advances in the adjustive mechanism of the animal. As yet the story seems to be a story of mechanical progress; or, to avoid an ambiguous term, a story of the progress of mechanism. We have found such remarkable purposive results achieved in the invertebrate and lower vertebrate world by an admitted mechanism that the slender claims made for any other than neural agency seem inadmissible. Those results have, apparently, not been sufficiently considered by the few observers who would, even at this level, introduce a mystic element to supply what they think to be the incapacity of the nervous machinery.

Few modern authorities take up this position, however. More usual is the opinion expressed, with some hesitation, by Principal Lloyd Morgan, who admits that we can in no case (up to this point) declare the nervous mechanism incapable of performing the act in question, but suggests that a dim and growing consciousness may *accompany* it. On this view the consciousness would stand somewhat in the place of the buzzing of a machine, or the incandescence of the lamp filament; it would do no work, but arise from the work. In fact, since Lloyd Morgan does not regard mind as a separate reality, but a different aspect of the nervous reality, or the ether of which it is ultimately compacted, his view is bound to take this form.

The detection of any such accompanying consciousness is, as he recognises, extremely difficult. If it is not a positive, interfering link in the chain of cause and effect—if the series of neural changes *may* be the entire cycle from the impact of the stimulus to the action of the animal—we cannot directly infer the presence of any state of consciousness, especially when automatic actions so often simulate intelligence. The only argument for it is that, long afterwards, the neural activity certainly has this other aspect—in man, for instance—and no one with a comparative knowledge of nervous systems would now attempt to revive Descartes's opinion that consciousness begins abruptly with man. Where, then, does it begin to dawn?

Besides emphasising the point that Principal Lloyd Morgan's view does not conflict with my main thesis—that no new reality has as yet entered the cosmos—I would venture to make only two observations on this delicate issue. The first is that, while Lloyd Morgan admits only an "accompanying" and vague consciousness, his arguments seem to demand a substantive and intervening consciousness. If the limpet has not "a mental image" of its home, as Romanes said, and if this—as distinct from a specific impress on its nervous system—is not a link in the causal chain, we seem to have no use for consciousness in it at all. But he seems to imply that we *have* a use and a need for it. His instances, in other words, either prove that substantive reality of mind which he denies, or prove nothing.

The second point is that the need to admit the dawn of consciousness somewhere down the animal scale must not yet disturb us. Few have any doubt to-day that consciousness is in man associated with his cerebral cortex. This is represented in the highest animals we have yet studied—if it is represented at all—by so slight and rudimentary a tract that analogy would rather dispose us to question very seriously the presence of consciousness at such a level. When the cerebrum begins to rise, among the different elements of the brain, in the early mammal and bird, the analogy really begins. Apart from the peculiar development of the insect, which we will consider, we are quite justified in postponing the question of consciousness. Let us take the world in its natural order. There is no proof that consciousness had appeared before the Devonian period, or has since developed in any of the modern representatives of Pre-Devonian animals. But we have now reached a stage when the theatre of life is to be profoundly changed, and the living things deeply affected by the change. In the accumulating effect of those changes we may find a reason why consciousness enters late on the stage of the world.

CHAPTER VI

THE INVASION OF THE LAND

In the early days of evolutionary science the imagination was no less puzzled than impressed by the procession of living things which the paleontologist drew across the stage of our planet. The primitive microbes clustering in colonies of cells: the roundish globules shaping themselves into the countless and diverse forms of invertebrate life: the emergence from the ocean to the land, and the ascent to the insect on the one hand, the reptile, bird, and mammal on the other: the slowly changing dynasties of the planet, culminating at length in the appearance of man—all this presented a superb spectacle, but one wondered why there was this persistent advance at all in the character of the earth's populations.

To this question half a dozen answers are offered in the name of Lamarckism and Neo-Lamarkism, Darwinism and Neo-Vitalism, Weismannism and Mendelism. It is, happily, not necessary for the issue of this work to weigh their conflicting claims. Neo-Vitalism, indeed, which offers no real explanation in postulating a mysterious directive principle within the living things themselves, is already excluded by the preceding chapters. Mendelism must find a much broader empirical basis, as far as it applies to animals, before it may be admitted to have superseded the assumption of the other schools, that the advance from species to species was generally gradual and continuous. But whether acquired modifications be transmitted or no must be left open in this inquiry. Not only an extensive American school, but such European authorities as Sir W. Turner, Professor Darwin, Delage, Eimer, Zehnder, Plate, Haeckel, Hering, Standfuss, &c., still adhere to the doctrine which Weismann has assailed.

The only point that is material to the present study is the influence of environment. I leave it open whether the changes in the surroundings of life, which I propose to show as most important agencies in the evolution of mind, acted directly or indirectly; whether they merely meant a change in the selective or destructive action of nature (for which there is ample room even in Mendelism), or in some way stimulated the variational tendency of the germ-plasm, or brought about certain modifications of organs which were transmitted in heredity. These are rival interpretations of a past process, which present experiment seems hardly competent to decide, and it would be unwise to build here on an exclusive feature of any one of them. But the action of environment in some form is admitted. It is a truism to observe that, if life is an adjustment of the animal's activity to its environment, any great changes in the environment will profoundly affect, or occasion a modification of, the living thing itself. Yet it may be doubted if the vast changes which the geologist describes in the story of the planet itself have been sufficiently appreciated on the biological side. We shall at least find that they have had a momentous influence on the advance of mind. The new and higher type of life was a response to the new world. The new theatre demanded a fresh race of actors.

In the present chapter we will endeavour to trace the long series of changes which issue in something like a revolution—as some geologists do not hesitate to describe it—and see how this revolution changed the face of the earth no less momentously than the French Revolution changed the face of Europe.

Broadly speaking, the surface of our planet in its earliest days showed much less land, and much more water, than now: no great mountains, and probably less deep abysses of ocean. When the water first spread over the crust, or soon after, there seem to have been only large patches of continent peeping out—in north-east America, the north Atlantic, and the region of Scotland, Scandinavia, and Siberia—which may have united in a far-lying continent. These—to neglect smaller areas—may have represented folds in the thin primitive crust or differences of level due to variations of pressure in the dense atmosphere. However that may be, the torrential rains wore millions of tons from the exposed surfaces, and laid them on the floor of the ocean. The increase of weight at the lower level forced the plastic mass inward, and mountains bulged into the air, dragging up with them fresh continental surfaces. In sum, the land gained on the water.*

I leave to a later stage the important question of the climate and the state of the atmosphere. It is enough for the moment to find the large northern continent emerging in early geological times. When one reflects how little advance in the direction of mind has been made by any aquatic (gill-breathing) animal, the importance of this physical process is apparent. Would consciousness ever have appeared on our planet, if the continents had not provided a new home for the living thing?

Round the shores of this northern continent, we saw, life swarmed and struggled, and has left its broken record in the rocks. In the Cambrian formations it is the debris of an invertebrate aquatic population : in the Silurian the fish appears. From the increasing struggle in the water both plants and animals now spread to the land. The details of the great migration do not concern us. Botanists are agreed that the Algæ gradually crept from sea to shore, evolved into moss and fern, and drew a thin mantle of sombre verdure over the land during the Silurian period. "We can," says Sir A. Geikie, "dimly picture the Silurian land with its waving thickets of fern, above which lycopod trees waved their fluted and scarred stems, threw out their scaly moss-like branches, and shed their spiky cones."

* See Sollas's "Age of the Earth" (1905). The crumpling of the crust from mere shrinkage is much disputed.

Of the animal life of this early continent we have very slight trace : some disputable scorpion-like animals, and fragments of primitive insects. It is suggested by some that the atmosphere was too thick and coarse for air-breathers to flourish; by others that the low continents, alternately rising and falling, offered a very insecure tenure.

What is clear is that the land-plants are now spreading over the continent, and that the new world gives occasion for a new animal birth. Certain animals, probably worm-like in origin, follow the vegetation, are adapted to breathing air, and advance to the highest level of the invertebrate world —the level of the Tracheates. I have postponed the general question of temperature, but even Professor Chamberlain, the chief representative of the dissentient school, admits that the climate of the Silurian period was much more uniform—more uniformly hot—than the present climate of the earth. This great northern continent, stretching into the Arctic, shows everywhere the same semi-tropical vegetation, and we find corals and other warm animals in all latitudes. It was not merely a new home but a forcing ground for the invertebrate world.

These conditions are maintained in the succeeding or Devonian period. How, at the beginning of this period, fresh mountain-masses arose (in Scotland and Scandinavia), and a fresh expanse of land emerged from the water, may be learned in works of geology. One of the characteristics of the period is that the new continents, including a good part of what is now Great Britain, enclosed large inland seas, in which the Old Red Sandstone was deposited. It seems to have been from these seas that the fish migrated to the land, possibly owing to the increased pressure of life in the evaporating seas. The adaptation to air-breathing does not concern us, and offers no difficulty in principle to the zoologist. In the fish an air-bladder (possibly a glandular cœcum in the early sharks) has developed, which, by contraction or expansion, can increase or reduce the weight of the animal as it rises or sinks in the water. In many modern fishes this bag of gas probably assists in respiration; in many it is double, in others connected with the gullet. The lungs are generally believed to have been developed from this apparatus.

There are in Australia, Africa, and South America to-day fishes with both gills and lungs (Dipnoans), which well represent the amphibian fishes whose remains are found in the Old Red Sandstone. It is instructive to find that in them the brain is well developed, and the sense-organs of the skin (which possibly respond to undulations in the water or air) are now confined to the mouth. We need not, however, linger over this fresh development of life. The life of the mud-fish calls for no special inquiry, after our examination in the last chapter. The *Lepidosiren*, it is true, closes the hole in which it burrows during the dry season with a plug of mud, perforated with holes, but this is one of the hereditary practices which come under the title of "instinct."

The change from water to land was of great importance, and we shall see that a higher type of animal soon evolved from the mud-fish. Possibly the atmosphere was, as most geologists think, extremely dense, foul, and murky in the Devonian, but the change had organic consequences of a far-reaching character. The upper chamber of the heart, which is only two-chambered in the fish, now sub-divided, and the organisation made a beginning of the separation of oxydised from venous blood which means so much for the higher animal.

How the rise and fall of land-surfaces, the mingling of arms of the sea with differing animal populations, the whole prolonged disturbance of the Old Red Sandstone period, must have deeply modified and stimulated the swarming invertebrate life of the waters, may now be left untold. We have done with the Invertebrates, save for that higher branch, the Tracheates, which will occupy us shortly. These characteristics of the period, which Professor Chamberlain has so well described, may, however, be borne in mind as illuminating the general upward development of life. For the moment let us return to the land.

The record runs that in the Devonian period there is an increase of land and of terrestrial vegetation. The land generally lies low, and the plants spread over the virgin swamps. The direct exposure to the air and to whatever solar radiation there was quickened the plant-world, and the ferns. club-mosses, and mares'-tails grow to vast proportions. The patches of sober-toned vegetation, unrelieved by flowers, are thickening into the dense forests which give character to the following (Carboniferous) age, and are now squeezed into the coal-seams of our crust. Their growth is checked at the end of the Devonian by a deep submergence of the surface of Europe. Then a fresh mountain chain, which partly survives in the mountains of central Germany, rises out of the European ocean, running from Brittany across central Europe, and drags the surface towards the water-level. A vast area of rich swamp is exposed, and over it the new vegetation spreads luxuriantly. In our coal we have the remains of the great forests that sprang up from the Arctic to the Equator, and even in Australasia: from north America to Europe and China. "Nearly all over the globe," says Mr. Drew, "the climate was the same—hot, close, moist, muggy."* The mares'-tails grew to a height of twenty or thirty feet. The Lycopods, which now rarely attain three feet in height, reared their heavy crowns one hundred feet above the thickets. The ferns provided a rich undergrowth in the noiseless, flowerless forests.

As the coal-measures are in places (as in Arkansas) 18,000 feet thick, it is believed that the great forests must have lasted from one to two million years.

* "The Romance of Modern Geology" (1909), p. 219. The geological details I give are based on a careful comparison of the latest editions of Chamberlain, Le Conte, Geikie, Lapparent, Suess, Walther, &c., with due regard to the most recent discoveries and suggestions.

What this meant for the development of life can hardly be estimated. Some idea may be formed by recalling the biological value of the tropical forest, with its constant and teeming fertility, and the ensuing struggle for life. Spread this forcing-ground of life from Spitzbergen to New South Wales, and the direct biological influence of the coal-forests may be imagined. Amongst other forms the insects develop abundantly. Gigantic insect forms are found in the coal-measures, but the types are still simple and generalised. The higher and more interesting insects appear much later, and we may defer our examination of them. Let us follow the development of the vertebrate amid the succeeding changes of the earth's surface.

The first dynasty of terrestrial Vertebrates is the group of the Carboniferous Amphibia. Giant salamanders and other types of amphibious animals have left their remains in the Carboniferous rocks. Clumsy, sluggish animals, with long tails and weak limbs, waddled in the mud. Whether they descended from the Devonian mud-fish, or came from another branch of the fish-world through a separate adaptation to air-breathing, is disputed. The mud-fish at least illustrates such a transition. The land was steadily rising and providing more permanent surfaces, over which plants and animals spread, with increasing struggle and differentiation. Archegosaur, a salamandrine form, three and a half feet long, with paddle-shaped feet and fish-like scales and teeth, was a familiar feature of the transition.

Large numbers of other types wandered in the swampy forests of the later Carboniferous period.

Again I do not propose to linger in discussing them. The result of the efforts to trace consciousness in the higher Amphibia of our time has been so unsatisfactory that we may be content with a glance at this early land-dynasty. The instances of mental action offered to us are of the same order as the features of fish-life which we studied. Frogs and toads can be more or less tamed, or may so far overcome their instinctive habit of flight as to linger near, or take food from, a human being. That in such experiences a new association is formed in the animal's brain, which will henceforward modify the instinctive impulse to move away when the image of a large moving body falls on the dull eye, can hardly be doubted. That the animal reasons as to the character of the perceived object is incredible. It seems more natural to conclude that we have here an associative process which may be later illumined by consciousness, when the organ of consciousness develops. As yet it is a mere rudiment, if it exists at all.*

Interesting as it would be to dwell on the extraordinary adaptations of the Amphibia to their environment, since hardly any group is richer in obvious adjustments to special surroundings, we must pursue the story of the earth. Two important

* It must not be supposed that the moment there is a cortical layer, we have an organ of consciousness. We shall see that the greater part of the human cortex has not this significance.

changes were proceeding during the brief reign of the Amphibia. The forests were purifying the atmosphere, and the land was rising nearer to the cold level. These combined changes led to a marked lowering of temperature in the Permian, and opened a new chapter in the story of the earth.

Here it may be thought that my argument rests on a theory of terrestrial development which, though still accepted by the great majority of geologists, is now seriously challenged. As it is important not to rely in so essential a part of the argument on disputed statements, I must explain the situation with some fulness.

Until recent years geologists took from astronomy their theory of the earth's early development. The theory, which has been briefly sketched already, implied that in the condensation of the primitive earth, the gases remained on the outer fringe, as atmosphere, while the solids gradually cooled and received their burden of water from the shell of cloud. It was supposed that this primitive atmosphere was at least 200 times denser than the atmosphere we now breathe, on account of the presence of vast volumes of carbon dioxide. The basis of the estimate is the fact that the Carboniferous forests absorbed 200 times as much carbon dioxide as there is in the atmosphere to-day. Professor Chamberlain, one of the leaders of the new school, admits tnat the coal-forests would strip our atmosphere of its carbon in a hundred years; and they lasted at least a million years. The further conclusion was drawn that the climate of the earth, owing to this dense atmosphere, was semi-tropical from pole to pole; that there were no appreciable zones of climate and no seasons, but a murky, cloud-laden, moist summer all the year round, all over the known earth, until the close of the Carboniferous, when the atmosphere was relieved.

Paleontologists found the fossil remains of animals and plants quite in accord with this theory, and the vast majority of them adhere to it. However, a new astronomical theory set forth by Professor Chamberlain, and certain discoveries in geology, have brought out distinguished dissentients, who say that there is no proof that the Paleozoic climate was materially different from the later, and some proof that it was not different. Glaciation is claimed in Australian rocks of the Cambrian period. Salt-strata are said to oppose the theory of moisture. Volcanic eruptions are said to be enough to account for the volumes of carbon dioxide absorbed by the coal-forests and Carboniferous rocks.

Beyond observing that the planetesimal theory of Professor Chamberlain, which is the chief ground of these claims, seems to be wholly opposed to all the evidence that astronomy affords on the evolution of worlds, I refrain from discussing it here. Nor need I delay with the Australian claim for glaciation in the Cambrian. All that concerns my purpose is that from the Silurian to near the end of the Carboniferous there was over all the known earth, a very warm, dank, muggy climate, with an atmosphere densely laden with carbon dioxide; and this it would be difficult to contest. Professor Chamberlain grants that in the Silurian and Devonian there is "much to suggest uniformity of climate," and that the lower Carboniferous climate seems to have been "essentially uniform, genial, and moist." The sub-tropical vegetation spreading from Spitzbergen to Australia in the Carboniferous plainly points to this. On the other hand, it is not disputed that the climate fell considerably, that trees of the pine and yew character appear for the first time, and that fields of snow and ice covered large stretches of the earth's surface, at the close of the Carboniferous.

It is agreed that the vast proportion of carbon dioxide in the Paleozoic atmosphere was the chief cause of its high temperature and moisture; a contributory cause may be found in the lowness of the land and its smallness of area as compared with the ocean. Both these causes were removed in the Carboniferous period. The vast forests compressed into our coal-seams represent an extraordinary purification of the atmosphere; even the Carboniferous limestone, Professor Chamberlain says, absorbed as much carbon as there is in our whole atmosphere today. It does not affect my point whether this mass of carbon lingered from earliest times, or whether—as the new school says—it was ejected from volcanoes. The earth was stripped of its "blanket," and, although the sunlight would now fall on it more freely, the immense radiation into space would reduce its temperature materially. The effect would be the same as when one passes from the valley to the summit of the hill.

At the same time, by a sheer coincidence, the level of the land was raised appreciably. The American continent was lifted and greatly enlarged by the rise of a chain of mountains; Europe was lifted up and enlarged owing to the rise of the Hercynian chain; the Siberian land was similarly extended; and a new continent—Suess's Gondwana Land—stretched from Brazil across Africa to India and Australia. The "dim, watery woodlands" of the Carboniferous were raised into dry and firm continents. The new mountain-ranges gathered the aerial moisture about their summits, and in some places become snow-clad alps, on which glaciers glittered in the sun. The vast swamp-flora found its area enormously restricted, and the forests shrank into modest proportions. In the higher regions the plant evolved into a type more fitted to withstand the cold. For the first time we meet trees with the rings in their trunk which indicate seasonal changes. The Paleozoic age ended, in the Permian period, with a transformation of the face of the earth.

Some geologists have spoken of the change as a revolution, but the phrase is contested on the ground that the movements were gradual and prolonged. From the present point of view it is quite fitting to speak of revolution. The change in climate, vegetation, and whole environment had a profound effect on the animal population. Of 10,000 Carboniferous species only some 300 survived at the end of the Permian (Chamberlain). It was one of those periods in the story of life when evolution is quickened to its highest pace, and organisms perish in appalling numbers from unfitness to meet the new conditions. From the prolonged struggle with the new environment new types were bound to emerge.

Had this terrestrial revolution been permanent, the dynasty of the planet would have speedily changed. The rulers of the earth were no longer the transitional Amphibia of the Coal-forests. The Reptiles, to which some of the Amphibia insensibly lead, had appeared. Both on the southern and the northern continents they begin in the Permian to oust the Amphibia. From the first they divide into two great groups, the Diapsida and Synapsida, which probably differ in their amphibian ancestry. As the sequel will show, these groups were differently fitted to adapt themselves to the new conditions. The Synapsida—to follow the prevalent view—were the more plastic; the Diapsida would become a race of prodigious power if the conditions of reptile life continued. But those semi-tropical conditions were, as we saw, apparently doomed.

Unfortunately for the higher development of life, the crust of the earth now largely entered on the opposite process of demergence, and a genial climate prevailed again over areas that had been momentarily raised. In the Permian there was more dry land exposed in the region of Europe than there is to-day. In the Triassic it slowly sank again, and there was a period of salt-lakes and sandy wastes, with a warm, dry climate. In the Jurassic there was a further subsidence, and Europe became a vast coral-ocean, with groups of islands emerging from the water.

Those large changes of political conditions which men call revolutions once more supply a parallel to the earth's story. The first terrestrial revolution was only partially successful. In the reaction which followed, the less progressive of the Reptiles could prosper. An intermediate period, the Mesozoic age, intervened before a second terrestrial revolution would complete the work of the first. The story of life entered on what is called the Age of Reptiles.

It is needless for us to discuss the vast and varied forms that now spread over the habitable earth. Psychic life makes no great stride when we pass from the Amphibia to the Reptiles, nor may it be conjectured that the giant forms of the Jurassic period attained an intelligence which does not survive in the turtle or crocodile of to-day. One of their most remarkable features was the extraordinary smallness of their brains. The Brontosaur, whose frame probably weighed 90 tons, and ran to a hundred feet in length, had a brain which cannot have weighed more than that of a nine-pound human infant. The Atlantosaur and Diplodocus were no more highly endowed. Colossal megalosaurs, measuring from 50 to 100 feet from snout to tip of the tail, had brains no larger than one's fist.*

The flying Pterodactyl or Dimorphodon had no great advantage in nerve over the heavy-armoured Stegosaur or the leaping Deinosaurs. It was an age of brawn. There were no higher carnivores to find the weakness of the vast reptilian bulk and tough armour.

The scattered survivors of the Mesozoic dynasty are more endowed with brain, in proportion to frame, than the luxurious kings of their golden age, yet few and poor attempts have been made to detect in them anything more than the automatic working of their nervous machinery. Romanes gives as one of the most cogent illustrations of reptile intelligence a story of a cobra. The animal thrust its head down a narrow hole, and swallowed a toad. Finding itself then unable to withdraw its head, it disgorged the toad. Once again it inserted its head, swallowed the toad, and was forced to disgorge. At last it seized the toad by one leg and drew it from the hole.

The observation seems to illustrate very aptly the association and conflict of stimuli, of which I spoke, rather than the position of Romanes. Even a low grade of intelligence might have perceived, at least after a first trial, the futility of swallowing the toad within the narrow crevice. On the other hand, the

* It is calculated that it must have taken two seconds for a stimulus to travel from the tail of *Diplodocus* to its brain, and two for the return message to the muscles.

incident seems to fall fairly under the analysis I have earlier offered. That there is memory in fishes, amphibia, and reptiles cannot be doubted. But that this process is more than a retention of the impresses of stimuli received—that it is a conscious process—we have no ground to assert. Again, that the recorded stimulus is, in our own nervous system, and presumably in lower animals, physically associated with new impressions of a related nature, is an elementary assumption of physiology. In the cobra's brain there would assuredly be a conflict of recorded and actual stimuli, and there is nothing whatever in the observation to prevent us from assuming that a recorded successful experience of seizing prey, in unusual conditions, by the leg or other part, ended the conflict in the animal's brain.

One may give the name of sagacity, or reason, or imagination, or intelligence, to such a process, but the precise value of the term must be defined. It must not be understood to include consciousness. Not only is the nervous machinery capable, apparently, of discharging the function without consciousness, but the organ of consciousness is in a very rudimentary condition in the reptile, if it be developed at all. The part of the brain which in higher animals is associated with consciousness is in the Amphibia and Reptiles extremely small, and cannot with any confidence be regarded as indicating consciousness at all. Its primary function seems to be the reception and association of stimuli, and the transmission of impulses to certain muscle-groups. Whether it does anything more than this in its very primitive reptilian proportions may very well be doubted.

External observation helps us little. I have already pointed out the difficulty in discriminating conscious emotion from the nerve-disturbance which is in us the physical basis of emotion, and the physical cause of the external manifestations; and we found an analogous difficulty in regard to "intelligence." On that ground I submit that the test of mental action which is employed in recent works of comparative psychology—"the method of trial and error," or "learning by experience"—is little less fallacious than the older tests. There is a taint of anthropomorphism in the very phrase. In its strictest expression, what we observe in all the cases adduced is that the animal departs from its normal and hereditary mode of action in virtue of an individual experience. On what ground can it be contended that the nervous system is incapable of such adjustment? One may, indeed, go further, and say that our present knowledge of the intimate correlation of mind and nerve essentially implies that in such experiences a new association is formed in the nerve-centre itself, and has, especially after some iteration, an inhibitory or modifying effect. It is a new element in the machinery of response to stimulation; a new physical element. Unless we have independent ground to believe that the process is conscious, we are compelled to confine our explanation to the neuro-muscular mechanism.

This analysis applies to the observed actions of the turtle, the serpent, or the crocodile, no less than to the frog or the fish. Habitual practices are not now adduced as indicating intelligence, however complex and purposive they may be, and must be set aside. Our study of "instinct" in the insect will amply cover them; if, indeed, we have not already seen enough of the unconscious selection of elaborate purposive actions. Thus, for instance, the turtle's practice of hiding her eggs in the sands, and then returning to the sea by a different path, is still sometimes cited as an indication of intelligence. Since the double path rather increases than hides the traces leading to her nest, one would be inclined to look on the practice as more probably a purposeless reminiscence of some ancient practice. In any case, it would fall in the category of selected habits, assuming it to be useful. Other writers point out that the turtle has a singular power of recovering its own locality even after it has been removed vast distances. It is one of those instances that prove far too much. Only an intelligence of a high order could effect this, if the faculty were of the order of intelligence; but the power to find its way through the pathless waters of the ocean, with no glimpse whatever of the remote goal, is evidently not related to consciousness, but to one or other of the obscure modes of sensitiveness of the lower animal.

Recent writers more commonly adduce as an indication of intelligence, or "learning by experience," the fact that reptiles (snakes, lizards, &c.)

can be tamed. I have, in the case of the fish, submitted that this means no more than the formation of a new association in the nerve-centre. A lizard will react differently, in point of rapidity, according as the provoking stimulus is a slowly crawling caterpillar or an agile grasshopper. Dr. Guenther sees intelligence in this, but most writers would ascribe it to "instinct," or inherited mechanism. It is plain that the difference of the reaction—a leisurely movement or a pounce—is due to a difference in the association with the visual impression. In fact, most of the animal's instinctive movements in securing food must be due in some measure to unconscious association. It seems to be an extension of the same associative process that we have in the taming of fishes, frogs, lizards, and snakes. My own careful observation of the behaviour of a tortoise, which was given to a group of children, was quite consistent with this view. At first there was the hereditary shrinking into the shell whenever it was handled or approached. After a few weeks it was "tamed," and freely extended its head to allow one to stroke its neck. The very slow readjustment of behaviour in spite of persistent "education," had all the character of the fixing of a new association in a sluggish nervous frame.

Mr. Headley, who quotes these familiar phenomena of reptile life, grants nevertheless that the reptiles are "singularly wanting in intelligence."* The phrase sufficiently indicates that the writer, like

* "Life and Evolution," p. 92.

many others, deals much less critically with "mental" than with other features of animal life. He has previously examined the cerebral hemispheres of the reptile, yet, in face of their extreme scantiness and rudimentary character, can regard as "singular" the very low psychic activity of the animal. The central point of the whole problem is the condition of the cerebrum; and we are so little confident, even in the case of man, which areas of it are associated with consciousness, and so wholly ignorant whether these areas are in any degree developed in the reptile, that our conclusion must be one of great reserve.

To external observation the frog and toad, the lizard and the snake, indicate no process that may not be fairly ascribed to the working of their nervous systems; though, on the other hand, the observations do not exclude the claim that the animal may be to a slight extent conscious of the processes. Anatomical dissection leaves us in the same position. We can, therefore, only conclude that no agency distinct from the animal's neuro-muscular mechanism has as yet made an appearance in the scale of life, but that we must leave it an open, and possibly unanswerable, question whether some faint degree of consciousness is now associated with that mechanism. Possibly the analyses we have yet to make will point rather to a negative reply. Possibly the comparative anatomist of a remote generation will be able to give a precise answer in each case.

We turn aside, then, from the giant Reptiles that ruled the planet in the Mesozoic interval between the Permian and the Cretaceous revolutions, and prepare to follow the fateful fortunes of the more progressive or plastic Synapsida. In these or their descendants the cerebral hemispheres were destined to expand until they formed a vast and intricate mechanism, overarching the whole of the other contents of the skull. To what causes this momentous advance was due, and what it involved in the psychic life of the animal, is the next stage of our inquiry. But it will be remembered that we have not yet followed the evolution of the insect, and this must be done in the next chapter. The procedure, however unusual, is perfectly sound. It is now generally admitted that the higher insects come next to the birds and mammals in the psychic scale. We shall see that there is a very intelligible reason why they come into this association, though they are so far removed in the zoological scale. They shared, with the bird and the mammal, the full influence of those revolutionary perturbations of environment which throw so much light on the advancing procession of the animal populations of the planet.

CHAPTER VII

INSTINCT AND INTELLIGENCE IN THE INSECT

The evolution of the insect is still very obscure, but two circumstances point with some clearness to a descent from a primitive Annelid. The familiar larval form, the grub or caterpillar, disposed even earlier zoologists to look to the more advanced members of the worm-group for its ancestry, and recent science has been fortunate enough to recover one of those "living fossils" which have given so much aid in reading the record of paleontology. The Peripatus, a caterpillar-like animal which is found on the site of the old southern continent (South America, South Africa, and Australasia), proved on close examination to be "a kind of half-way animal between the Arthropoda and the Annelida."* So singular are its anatomical features that zoology has been obliged to frame for it the special class of the Protracheates. While it is a true Tracheate in breathing, it has the most striking affinities with the Annelids. Its nervous system consists of a pair of ventral cords, imperfectly thickened into ganglia at each pair of legs, and a couple of supraœsophageal ganglia.

* "Camb. Nat. Hist.," vol. 5.

From some such ancestor, probably in the Silurian period, it is believed that the vast kingdom of the Tracheates (myriapods, spiders, and insects) has descended. Haeckel derives the spiders and insects from the early myriapods; others regard the myriapods as an offshoot of the early insects; the majority of students trace the three classes to a primitive Peripatus, which in turn is derived from some branch of the Cambrian Annelids. To the spider we will presently return, but we may pass over the myriapods. The more curious phenomena observed in them—such as the action of the female *Lithobius* in hiding her eggs from the devouring male—are ascribed to "instinct."

The insect makes a first doubtful appearance in the Ordovician, in which, it is claimed, a wing of an hemipterous insect is found. Undoubted insects occur in the Devonian, and, as the vegetation increases in the Carboniferous, and the proportion of carbon dioxide is reduced, they increase rapidly in number and size. They are all of the generalised character which the theory of evolution expects. Scudder, one of the first authorities, would put them in a distinct family, but they are generally regarded as very primitive forms of the simplest of the existing orders. About 90 per cent. of them belong to the Orthoptera and Neuroptera. Gigantic Phasmidæ, nearly two feet long, represent in their primitive frames the grasshoppers, locusts, preying insects, &c., of a later date (Orthoptera). Large ancestral Neuroptera give promise of the mayflies, dragon-flies, &c. A few Hemiptera (aphides, &c.) and Coleoptera (beetles, &c.) also are found. The higher orders have not yet appeared.

The Hymenoptera (bees, wasps, ants) do not appear until the Jurassic period—more than ten million years after the beginning of insect life, on the lowest estimate, subsequently to the first great geological revolution and on the eve of the second. There is, however, reason to believe that the advanced insects of our time are much more recent even than this. In the Tertiary period there is a vast extension and differentiation of insect life. In the Miocene more than a hundred species of ants are found in one European district, whereas only some fifty species are now found in the whole of Europe. Le Conte observes that these ants were nearly all winged, and that therefore the remarkable social life of the modern ant had not yet evolved. However that may be, it will be instructive to remember presently that the only insects in which intelligence is claimed do not appear in any form until the second half of the Mesozoic period, and do not seem to have developed their more remarkable characters until much later.

These geological indications suffice to justify my procedure in deferring the question of the mind of the higher insect until the last phase of terrestrial evolution. Apart from the Hymenoptera we have, says Mr. Hobhouse, "remarkably scanty" indications of insect intelligence. Why the scantiness is "remarkable" it is difficult to see, and indeed it may confidently be stated that we have no such indications, unless it be in the case of the Termites, which we will consider later. I find only two claims made for the more than 200,000 species of the seven orders. Romanes gives a story of a house-fly that became so tame as to take food on a man's finger. The authority is not clear, and in any case the incident is covered by our previous analysis of cases of taming. Lloyd Morgan observed an action of a dung-beetle which seemed to imply intelligence. Rolling its ball of dung down a sandy slope, the ball was caught in a depression, and refused to stir. The beetle then scraped away the sand on the downward side of the little depression, and was thus enabled to proceed with the ball.

The chief difficulty in such instances as this is that if we grant intelligence at all, we must grant more than the general organisation and general behaviour of the animal seem to admit. An intelligent child of two, if not three, years would hardly conceive such a device. On the other hand, this isolated observation gives us no information as to what the beetle usually does in such circumstances. The mishap cannot, in view of the beetle's habits, be an unusual one, and we have no assurance that the action was a novel and non-instinctive adaptation to the circumstances. The well-known co-operation of dung-beetles to surmount a difficulty prepares us to expect somewhat varied ways of reacting on special stimuli. We do not seem justified in laying any stress on this particular observation.

But, if these are the sole claims for something like intelligence in the seven orders of insects below the Hymenoptera, the instances they afford of striking habitual action, of a purposive character, are almost innumerable. These processes are all summed up in the one formula "instinct," and it will be necessary to premise a few words of analysis before we examine them.

Instinct is one of those words which ought, in the interest of mental science, to be erased from the dictionary. One has only to recall the abundant mischief that is still done by the older habit of contrasting instinct and intelligence as two distinct "faculties." The theory of faculties has had its day, and there are to-day few who fail to see that a blind, unreasoning power or energy is infinitely less satisfactory as an explanation of such far-reaching purposive activities than the evolution of unconscious mechanism itself. The work of more than one distinguished student of insect-life (such as Father Wasmann) is strangely warped by the idea that this mystic force—one may almost say, this mere phrase—is enough to explain the most intricate activities of the ant or the bee. "Its instinct tells it," is a phrase that ought not to be suffered even in the natural history books of children. Instinct can tell the animal nothing, and tells us nothing. Nor is its explanatory value in the least enhanced by a declaration that it is "immaterial" in nature.

In the next stage of comparative psychology—the stage of Romanes—when there was a natural tendency to overrate animal intelligence, it was suggested that instinctive actions had once been intelligent, and had become automatic from practice. Maeterlinck has given popularity to the idea in its application to the bee, but it is now generally discarded. To the vast majority of the insect's purposive activities it is wholly inapplicable. Neither present nor past intelligence can explain the remarkable actions of many larvæ (*Sitaris*, *Anthrax*, &c.), and very many pupæ (emperor moth, &c.), or the provision for young that the mother will never see. Wundt would still give the name "instinctive" to human actions that have become automatic, but most writers agree with Lloyd Morgan that we do better to confine the description to purposive actions that are and always were wholly independent of intelligence.

It is now usual, therefore, to discard the term "instinct," except in the sense of an abstract appellation of a certain group of animal activities, and to ascribe those activities in the concrete to natural selection. Mr. Hobhouse has well observed that the instinctive action is a function of a certain nervous structure, and that a nervous structure is just as apt a subject of evolution as a limb or a heart. We may even go further. The fate of an animal is so largely determined by its actions that natural selection must have an especially wide field in them, and so "functional selection" is now recognised as a most important aspect of evolution. On this principle—that the evolution of instinct is at the bottom of the evolution of a particular neuro-muscular apparatus—we have at last made some headway in the interpretation of these obscure processes. We have at least begun to understand their obscurity. Their origin lies in past geological ages.

If this is now the predominant feeling in regard to instinctive actions, it may be thought that we may at once pass over ninety-nine per cent. of the insect's activities, and proceed to discuss the wasp and the ant. For two reasons, however, it is inadvisable to do so. One reason is that, in the words of most recent writers, intelligence arises in the field of instinct, and there is grave difficulty in discriminating between the two in nature. The second reason is that we are asked to admit that consciousness may accompany the instinctive movements, though they are intelligent.

It is now necessary to define very accurately the nature of the terms we use, as far as definitions can be given. We may, as is usual, take man as the measure of things. We perceive in our own person mere physical actions (falling down), simple reflex actions (blinking), compound reflex actions (avoiding an obstacle), and instinctive actions (the sucking babe). The series has been so often discussed that one need not enlarge on it. We then cross the threshold of consciousness, and we have presentation (leading on to perception, judgment, and reason), memory, will, and emotion. It is not necessary for my purpose to borrow definitions of these conscious states. What it is most material to observe is that each of them has a corresponding physical or neural process. In other words, the series of nervous processes runs on from simple and compound reflex action into elaborate process of recording, associating, and inhibiting stimuli.

As most writers on animal mind now regard it as another aspect of neural action, and all writers admit a parallel series in mind and nerve—if only on the ground that the most abstract thinking and the most spiritual emotions use up the brain as much as manual work uses the muscles—this may be taken for granted. But it raises the question how far these physical processes may be found in the animal world without any consciousness. Take memory. Our nervous system records impresses—there are innumerable instances—which may not until long afterwards, if ever, enter the field of consciousness. The animal's nervous system does the same. If, then, the wasp or the frog "remembers" its hole, how can we claim that this is a conscious process? We cannot. I have illustrated the same difficulty in regard to emotion. There is undoubtedly in us a nerve-storm, as well as a state of consciousness, and it is this nerve-storm which causes the internal and external effects or manifestations of emotions. In sleep and under anæsthetics human beings often show the "emotion" without consciousness. How can we tell whether it is, or is not, a conscious process in the animal? It is not enough to say that we interpret the animal as we interpret our fellow man. His brain is a vastly different machine from that of the insect.

I wish to illustrate the real difficulty of discriminating between instinct and intelligence in the animal. If there is unconscious presentation, unconscious memory, and unconscious emotion in the animal, there is also unconscious thinking. After describing some of the more remarkable instinctive actions of the animal "machine," Weismann goes on to say:

"This regulation [of the machine] is due to the intelligence, the unconscious thought, which we find in a considerable degree in the highest animals, but which dwindles gradually in the lower until it ceases to be recognisable."*

This "unconscious thought" [*unbewusste Denken*] seems to be the neural process, corresponding to a simple act of reason, to which I drew attention. No one will suggest that the more elaborate nerve-processes which underlie our higher conscious states may be found in the animal without consciousness, but there is no reason why the simpler associative processes may not be so found. Unconscious inference is common enough in human experience. The rapid processes of reasoning which superficial writers call "intuition," especially in the case of woman, are largely unconscious. The whole subconscious life of the mind, as it is now admitted by

* *Vorträge über Descendenztheorie*, I, 172. It is regrettable that the passage has been so altered in the English translation as to convey the impression that Weismann referred to conscious intelligence. Elsewhere, as we saw, Professor Thompson himself speaks of "unconscious psychic processes."

distinguished psychologists, exhibits a remarkable extension of the same principle. It accomplishes at times complex acts of inference.

It is not a little significant that the chief reason why many psychologists reject the sub-conscious life in man is that they regard the idea of sub-conscious mental action as a contradiction in terms. The facts, however, are abundant and notorious. The conception of the mind as an iceberg, of which nine-tenths lies below the level of consciousness, may be greatly exaggerated, but it is quite true that our conscious experience is only a part of a larger whole. And the solution surely is that the larger whole is the neural machinery of the cerebrum, only part of which is associated with consciousness. On every side of the illumined area the machinery is prolonged in the darkness of unconscious nerve-action. The idea of a sub-conscious *mind* may or may not be a contradiction in terms. If mind is conceived as an entity distinct from the brain, the essence of which is consciousness, the "subliminal self" is an absurdity. The unconscious processes are nerve-processes, contiguous to those in the lit field of consciousness, and constantly passing their results into that field. Such a conception is at once in harmony with experience and anatomy, and is the only interpretation that avoids serious difficulties.

Now, if we are to interpret the animal's behaviour in terms of our own experience, we cannot overlook this important section of it. I have no disposition whatever to restrict non-human intelligence, but I submit that we have not yet found—up to this level of animal life—a sound test of its presence, and have applied the standard of human interpretation improperly. In interpreting the behaviour of animals very much lower than ourselves in cerebral organisation, we must first consult the lower segments or planes of our experience.

Professor Loeb, a novel and critical investigator, regards the possession of "associative memory" as a sign of intelligence. But there is memory, and associative memory, in our sub-conscious region, and it is not all plain why this should be refused to the competency of neural processes, and declared to involve consciousness in the animal. Nearly all other writers regard the power to learn by experience—the fact that an animal modifies its habitual, and presumably inherited, behaviour on the ground of an individual experience—as the best test. I have already pointed out that it is difficult to say when the behaviour *is* entirely new, though not habitual, but my chief point is that such an adjustment may be due to Weismann's "unconscious thought," to a process analogous to our own sub-conscious processes; or to the nerve-processes in an unconscious human subject. The few instinctive actions and the compound reflex actions in man are separated from the region of conscious life by a broad margin of unconscious processes which are analogous to acts of mind. You cannot ignore this field when you are interpreting the animal's behaviour in terms of human experience. You cannot claim consciousness the moment there is a departure from instinctive action.

On these principles we shall, it must be admitted, find it more difficult to interpret the phenomena of insect life, but we have no alternative. Six orders of the insect world—the Orthoptera, Aptera, Coleoptera, Diptera, Hemiptera, and Hymenoptera—may be dismissed briefly. A few of the more remarkable activities observed in them may be described briefly, to illustrate the general formula.

The dung-beetle (*Scarabæus*) buries its ball of dung in the spring for its own consumption, and in the autumn buries another for the feeding of the young, which it will never see. It even partially digests some of the dung, and makes a kind of paste for the delicate larvæ. The Sitaris beetle deposits its numerous eggs near the entrance of a bee's nest. Its larvæ hibernate until the spring, and then attach themselves to the coat of a passing bee, and are carried to the store of honey in the cells. They will attach themselves to any similar surface, and to the male bee—which is useless—as well as the female. The weevil makes wonderfully precise S-shaped cuts in a leaf, rolls it into a funnel (as the grocer does his sugar-paper), and deposits its eggs therein. As the larva is blind, the weevil has never seen such a nest before. The *Anthrax* fly deposits its eggs on the fortress of the mason bee, and the larvæ penetrate to the stores. The *Leucospis* penetrates the walls of the same fortress to lay its eggs. It seems to test the hard cement walls with its antennæ, and always bores through where there is a cell, not into the thicker masonry; but it does not perceive that the cell has already been penetrated by others, and that the bee-larva is dead and useless. The ant-lion digs a pit, in which it lurks for other insects, sometimes assisting their fall into the pit.

These are some of the most curious and arresting activities in the six orders of insects. Add to them the infinitely varied ways in which the mother conceals and provides for its eggs, and the wonderful contrivances by which the grub protects itself during pupation, and one has a good idea of the material to be analysed. By common consent it is put under the heading of "instinctive action." There is no need here to retail the many definitions by which recent writers have given a precise limitation to the phrase. As this kind of action passes insensibly into ordinary reflex action at one end of the scale, and into intelligent action at the other, such precision is very difficult. The essential point is that instinctive action is independent of experience or intelligence, yet complex and purposive, and is substantially identical in all animals of the same group. It is a compound reflex action directed to the unseen end of self-preservation or race-preservation.

Such action now concerns the physiologist rather than the psychologist. Whether some consciousness may or may not accompany the action it is futile to discuss; nor would it be easy now to quote a psychologist of any distinction who imagines that "instinct," as a faculty, sheds any light on these achievements. Such a notion was engendered in mediæval school-rooms, where speculation stood for observation. These activities are the functions of inherited nervous mechanisms, and it is the place of the comparative physiologist or the zoologist to trace their evolution. The difficulty of doing so is undoubtedly great. It is still complicated by the dispute as to whether or no acquired modifications are transmitted. But there is a grave inherent difficulty in the circumstance that the evolution of these instincts lies far back in the past, and such delicate nervous structures could leave no fossil impressions by which we might retrace their development. Some few principles of interpretation may be suggested when we have seen the even higher activities of the remaining insects.

In the order of Neuroptera the termite claims special attention for the elaborate nature of its social life and provision for the young. So closely does it approach the highest member of the insect world that it enjoys the unmerited title of the "white ant." There is, however, an important distinction. The present attitude of comparative psychologists is to overlook instinctive actions, however elaborate and purposive they may be, and seek mind only in deviations from the inherited type of behaviour. Such instances are not alleged in the case of the termite. It has not been so closely studied as the ant, and future observers may suggest instances. At present we have none to consider, and the whole life of the termite may be assigned to the previous category.

It may be pointed out that, as we shall see more fully in the case of the ant and bee, we are not without clues to the evolution of these very remarkable instinctive activities. Some species of termites build no homes, but live in decaying trees. Others of the same group go on to form partitions in the natural nest, with the aid of their secretions. Others burrow in the wood, and construct galleries from one place of security to another. So we rise gradually to the wonderful homes of the African termites, by which houses may be thrown up to a height of 20 feet and cemented with the animal's secretions, where the large queen—a mere machine of fertility—will lay her 80,000 eggs a day, and the tiny blind workers and nurses will care unceasingly for the coming brood, and the scythe-jawed soldiers will guard the colony. It is now generally believed that all are alike at birth, and that the different development is secured by feeding. As yet, it is said, we know less than a fourth of the insects that actually live on the earth; and these—a million in number—are a fraction of the species that have lived since the beginning of the Tertiary. The task of explaining their evolution is, therefore, a formidable one.

It is in the order of the Hymenoptera that we encounter the most serious claimants to mental endowment, and, as the normal activities of the ant, wasp, and bee have been so repeatedly described, I will confine myself to those alterations of normal conduct in which intelligence is detected. It must first be stated, however, that more exact observation has modified some of the earlier claims made on behalf of these animals. Perhaps the most impressive of all the recorded actions was that of the wasp which stung its caterpillar methodically in a series of ganglia, so as to render it unconscious, and thus provide a week's supply of live food for its young. The mystery, as Lloyd Morgan says, has turned out to be "one of our own fabrication." A series of fine observations, excellently recorded by Mr. and Mrs. Peckham in their "Wasps, Social and Solitary," have put a very different complexion on the matter. In spite of the fact that nothing short of a ridiculously high intelligence would suffice to make the wasp's action a conscious one, most people insisted that the practice raised the animal to a high level. On their own extensive observations of the stinging of the grubs and the condition of them when stored, Mr. and Mrs. Peckham were forced to conclude that "the primary purpose of the stinging is to overcome resistance, and to prevent the escape of the victims, and that incidentally some of them are killed and others are paralysed." To this admirable conclusion one can only demur that there is no obvious reason for inserting the word "primary."

This work on the wasps is one of the best collections of material on the question of the insect mind, and we may proceed at once to examine the symptoms of intelligence or consciousness. The work shows some bias in favour of intelligence. It is assuredly true that "the necessity of interpreting the actions of animals in terms of our own consciousness must be always with us;"* but it is equally true that our own *unconsciousness* has the prior claim to be consulted. Let us see if there is anything in these observations that rises plainly or probably above the level of our "unconscious thought."

The social wasps Mr. and Mrs. Peckham found to be "wanting in the higher gifts of emotion and intellect," but their observations relate chiefly to the solitary wasps. Broadly speaking, the work of the mother wasp—the father does not merit serious attention—is, after a season of pleasure, to make a burrow in the ground, provision it with animal food, lay her egg on the grub or spider, and seal up the nest. Differing from previous observers, Mr. and Mrs. Peckham found an enormous amount of variation and vacillation in members of the same species. Their instinct was by no means the "calculable and invariable" thing that Romanes was led to assume. When one reflects on the infinite diversities of nervous structure, or temperament, in our own species, the variability is not surprising.

Mr. and Mrs. Peckham also correct earlier observers on the question of paralysing prey, as I said. While the larvæ must feed for a week or more, the animal provided commonly died within two or three days. There were great variations in the stinging

* *Op. cit.* p. 293.

in different species, and some within the same species. In a large proportion of cases the young were doomed by the mother's "carelessness."

Further, they found many curious indications of lack of intelligence. *Bembex* has numbers of attendant flies at its nest, which will lay their eggs together with those of the wasp. The fly-larvæ will consume the wasp-larva's food, if not the larva itself, but *Bembex* never kills them. When a store of food was placed near a nest, the two or three wasps that found it did not inform the others, as ants would do. That the wasp is baffled if one removes the stone or earth which hides the entrance to its nest is an old observation, and must not be pressed; but that the wasps will, as the Peckhams observed, wriggle all day through blades of grass that are laid across the entrance, and not attempt to remove them, is a fact to be noted. It may be added that when the observers killed certain wasps, the others, so far from being agitated, calmly cut up the bodies as food for their young. Finally, the wasps not only exhibited a rigid and unintelligent refusal to accept spiders which were offered them, to save them the trouble of hunting, but in some cases a superficial show of intelligence proved to be quite hollow. Certain wasps seemed to disguise the provisioned nest with great ingenuity when it was sealed up. It proved, however, on closer examination that the "instinct" was quite valueless, as the chief robber was the ant, which burrowed underground for the buried spiders.

Against these habitual signs of unintelligence the Peckhams place other observations which, in their opinion, imply a certain grade of intelligence. All habitual practices, no matter how impressive, they, like other authorities, leave in the category of instinctive actions. To this class belong the numerous ways of nest-building, the scattering of the excavated material (which might betray the hole), the choice of animal food for the larvæ, the various methods of stinging and carrying the prey, the general practice of plugging the hole with earth after the eggs are laid, and the general facility for recovering the distant nest at once. On the latter point they hesitate at times. *Sphex* seemed to them to make an "intelligent" observation of the locality in which the hole was made before starting. The impression is somewhat anthropomorphic. They describe the wasps as making their way straight home along the ground in a way which entirely precludes any use of an observation of the locality; their homing power seems, as in other cases, to be connected with the more obscure sense-life of the lower animals. It is a common suspicion that insects have forms of sensitiveness that are as unimaginable to us as vision is to the man born blind. In any case, such a practice of visual observation no more implies intelligence than the habitual sealing of the nest.

The cases in which they observed a deviation from instinctive practice are not numerous. They point, in the first place, to the fact that, under the pressure of a change of surroundings, wasps will build in a medium other than the normal medium of their species. Insects that were accustomed to nest in hollow trees have now taken to the eaves and chimneys of houses. Few will follow them in claiming intelligence in such circumstances.

More in accord with the usual test of intelligence are the following observations. A wasp belonging to a species which usually leave the captured spider on the ground, while they make the hole for it, was seen to place its spider in the fork of a plant. As this prevented the ants from reaching the dead spider, it has an appearance of sagacity. Other wasps were seen to bring to their holes, already made, spiders which were too large to be dragged in, and they enlarged the tunnel leading to the nest. Another wasp was accustomed to leave its grasshopper near the hole while it entered and turned round, to drag in the prey. They removed the victim to some distance. Several times the wasp brought the grasshopper back, and turned round inside as before, and they removed its prey each time. At last the wasp would either drag the grasshopper backwards from the spot outside, or would force it down head foremost. In another case they were amazed to see a wasp grasp a small stone and beat down the earth over its nest, instead of merely butting it, as is usual.

These are, on the accepted test, some of the highest recorded instances of insect intelligence, and must be carefully considered. The first consideration that occurs to one is that, before one can say that we have here an individual improvement on inherited ways, we require strong evidence that the action *is* novel and individual. In the case of the *Ammophila urnaria* pounding the earth with a pebble in its mandibles, which greatly impressed the observers when they first saw it and has been regarded by other writers as the most striking indication, we are fortunate in having ample evidence. The Peckhams found other wasps with the same practice, and other observers, as they record, have seen the same practice in other parts of America. This at once reduces the value of the action as an indication of intelligence. Though the curious facts have only come to light in the last few years, the evidence already shows that it is an hereditary practice, not an individual deviation from it. It is on a level with the practice of the *Melicerta*, or the caddis-grub, or the tubular worm, in using material to build its tube. "Automatism," as Lloyd Morgan says, "no matter how complex or nicely adaptive, may be unconscious"; though Lloyd Morgan regards this action as intelligent.

As far as one can gather from Mr. and Mrs. Peckham's work, the action of the wasp in enlarging its hole to accommodate a large spider, or in biting off the spider's legs, is of the same category. One must not too hastily assume that this excludes intelligence. If many wasps were intelligent, the same device would be intelligently adopted by many. All that we can say is that the action is apparently not a clear case of enlarging on instinctive standards. Further observation is needed. And the same must be said of the wasp which placed its spider in the fork of a plant. On the face of the matter, it implies—if a calculated act—a grade of intelligence out of all proportion to the species to which the insect belonged. Is there a practice? And what is its extent? Instinctive practices, we must remember, must have had a beginning, and that beginning is now sought in chance variations of conduct, which happened to be useful and were selected.

Even in the fourth case—the wasp varying its method of dragging in the prey—we need more information. The presence of an experimenting human being was assuredly a new thing, but wasps commonly steal from each other (the Peckhams tell us), and half-paralysed insects may crawl. It is by no means clear that the action was novel. On the other hand, when a clearly novel and advantageous situation was created for the wasp—when insects were offered without the trouble of hunting them—the theory of intelligence completely failed.

In fine, we have to consider whether these actions, assuming that any of them were really novel to the species, were beyond the adaptive capacity of the unconscious nervous mechanism. They are of the same order as a dozen observations I have previously analysed, and I need not repeat the suggestion at length. If a new association (such as Mr. Hobhouse admits to be possible in the case of the tamed snake) in the nerve-centre is formed, a new action may issue from it. In the vast majority of cases the machinery proved too rigid to permit this, but if some were not more plastic and adaptable there would have been no progress. A large proportion of the "instincts" must have begun in that way.

Contrary to the popular impression, there is even less indication of intelligence in the bee. This popular impression is, however, grounded on the fallacy that intelligence is revealed in the high degree of complexity and purposiveness in instinctive action. The fallacy is, as we saw, now expelled from comparative psychology, and the demand is made for individual improvement on hereditary practice before the question of intelligence can be considered. One illustration from the bee-world will suffice. The mason-bee (*Chalicodoma*) builds an elaborate nest of a cement made of earth and saliva. It even economises labour by inserting suitable stones in the walls of its structure. But even while the mason is building, parasitic flies buzz about without being harmed, and they eventually destroy more than half of its progeny. The whole admirable architecture is the outcome of an unreasoning mechanism.

Impressive as is the social and hereditary activity of the more advanced bees, observers seem to have found in them no instances of enlargement of conduct on the ground of personal experience. The failure is somewhat singular, and one would not be surprised if it is remedied when the bee is more closely studied in the light of the accepted test of intelligence. Hitherto attention has been wholly directed to the normal habits of the various species, and has made it more improbable than ever that their highest practices are in any degree due to "lapsed intelligence." We are now acquainted with so graduated a variety of habits that speculation on their evolution is freely indulged. Hermann Müller, especially, and Hugo von Buttel-Reepen have drawn up plausible schemes of evolution.*

When the 1500 known species are arranged in order of complexity of habits we have a good suggestion of some of the lines of evolution; just as when we arrange the various races of men in a similar series, we find that it very largely corresponds to the known course of human evolution. We have first the solitary bees, which, like the solitary wasps, store food in the cell with the egg, and then seal it. We have then forms which (like the British short-tongued bees) exhibit a growing sociality. They burrow underground in families, but the several families may have a common tunnel, vestibule, and sentinel. Through various forms we rise gradually to the complex social life of the honey-bee, in which division of labour, the constant accompaniment of social life, has proceeded to a remarkable pitch. More recent research has, as in the case of

* *Die stammesgeschichtliche Entstehung des Bienen-Staates* (1903), by H. von Buttel-Reepen.

the wasps, cast a doubt on some of the traditional virtues (such as the reverence for their "queen" and the mathematical accuracy in construction) of the bee,* but it remains one of the wonders of lower animal life.

Maeterlinck has finely conceived a bee as philosophising with some disdain on the inferiority of human social arrangements, and Principal Lloyd Morgan has drawn an interesting allegory of a bee surveying a human community, and wondering if those slaves of habit are endowed with consciousness. It is none the less true that we cannot on any strict principle ascribe intelligence or consciousness to the bee. The appeal to the extreme complexity and usefulness of their habits is an appeal to the imagination, against scientific tests. A certain lowly caterpillar fortifies itself for its pupation in a cocoon, in which some stiff silk bristles are fixed so as to exclude an intruder, but permit the easy departure of the animal. Intelligence is out of the question; just as it is in the extraordinary mimicry of the walking-stick insect, or in the insects which have taken on warning colours. We cannot set a limit to natural selection, or whatever evolutionary agency may be favoured, in such matters.†

* See the excellent summary in Prof. Thompson's "Study of Animal Life": or the "Camb. Nat. Hist.," vol. vi.

† An even more remarkable outcome of evolution is found in the case of the *Anthrax* (or *Argyromœba*) fly. From the egg which it lays on the wall of the mason bee's fortress, comes a tiny larva equipped with a horny head and bristles. It must force an entrance into the bee's young. With extraordinary

At the end of the chapter we may discuss in a more general way the habits of the more advanced insects, as well as the question whether some consciousness may not accompany the working of their nervous mechanism. Let us first consider the ants. For this part of the inquiry I rely especially on the recent and authoritative work of Wasmann, Bethe, and Forel. The selection has the advantage that the three observers are of opposing creeds on the question of mind in the ant. Father Wasmann,* one of the most assiduous and informing of ant-observers, makes his material somewhat unattractive by an attempt to squeeze it into the narrow frame of a neo-mediæval philosophy, and by the arrogance of his references to his opponents. Forel holds the now current view that the intelligence which culminates in man has already made its appearance in the animal world. Bethe ascribes the activities of the ant and the bee to unconscious mechanism alone. From the three-cornered controversy we are in a better position to appreciate the life of the ant.

endurance and abstinence, it at length finds its way in. Here, as it must not kill the larva, but feed on living flesh, it entirely changes its form, and develops a delicate sucker with which to absorb the contents of the larva's body without wounding it. In the end it enters on the pupa stage, hibernates, and the next spring is found to have a formidable apparatus for cutting its way through the solid masonry. The insect world teems with wonderful adaptations and unconscious purposive processes.

* "Comparative Studies in the Psychology of Ants and of Higher Animals" (1905) and "Die psychischen Fahigkeiten der Ameisen," *Zilogia*, Bd. xi.

For the reasons I have already given I need not describe at length the normal course of life in an ant-community. Though doubt is still expressed on some of the virtues of the ants—as, for instance, that they deliberately cultivate fungi, and enclose aphides—the life of the higher species makes on the imagination a deep impression of intelligence. The sight of the nurse-ants receiving and licking the eggs, and putting the larvæ in earthy cavities for pupation; the posting of sentinels at points of danger (which Wasmann seems to have quite established); the nursing and healing of sick and maimed companions; the blockade and invasion by slave-raiders, on the warning of scouts, of the smaller ant-community; the disgorging of the full to feed the hungry—all these things have been described often enough. Few can observe them, or read of them, without experiencing a tendency to credit them with intelligence and conscious emotion.

Yet even Forel observes that the ants are "very stupid" in all that does not concern their instincts—a suggestive statement—and Bethe and Wasmann deny outright that they have any intelligence. Bethe, partly following Lord Avebury, made a series of experiments of great interest. Many observers had been impressed by the way in which ants recognised and received members of the community into the nest, as the workers (sterile females) are generally blind. Bethe bathed an ant of a rival colony in the body-juice of certain ants, and found that it was received as a friend. Wasmann has himself concluded that the so-called language of ants consists merely in attracting each other's attention by touches of the antennæ, so that they may follow to the discovered food or out of danger. In another experiment Bethe put a swing-bridge between the nest and the food. When the ants had crossed, he turned it about, and the ensuing confusion seemed to indicate that they had merely been guided by the smell of their own traces. He further showed, as Lord Avebury had done, that they would not heap up earth to the extent of one-third of an inch to reach the honey they smelt and coveted. A number of similar experiments were tried, and the lack of initiative on the part of the ants was made plain.

Wasmann adds from his observations many other proofs of unintelligence. *Formica sanguinea*, which captures the larvæ of, and enslaves, *Formica fusca*, makes no alteration in its company of raiders in proportion to the size of the invaded community, and often suffers severely; yet this ant seems to have a remarkable arrangement of scouts and other admirable tactics. The behaviour of ants toward the beetles which they curiously tolerate in their nests is also declared by Wasmann to be very unintelligent. They care for the larvæ of the beetles in the same way as for their own, though the beetle-larvæ devour their own very freely. On the other hand, the balance is restored by a curiously unintelligent feature of the ant's philanthropy. The beetle larva needs entirely different treatment from the ant-larva. The ant-nurses, however, take it from the dome of earth they have made over it, just as they do their own larvæ, and so unwittingly kill most of the young beetles. Admirable as the result is, the process must, Wasmann says, "utterly bewilder" the believer in ant-intelligence.

Yet it is in Wasmann's own pages that the comparative psychologist will probably find the strongest evidence. From Forel's answer to Bethe I gather only one incident that demands examination. He brought from Algeria a colony of ants, which were accustomed to leave open the entrance to their nest, and he found that, when they were bothered by members of his other colonies, they closed the nest with pellets of earth.* Wasmann took away the sentinels the ants had posted in his ingenious observation-nest, and he states that he then saw ants warning newcomers with their antennæ, and even pulling back an adventurous or obtuse worker who nevertheless went on. On another occasion he found that a colony which discovered some tar-paper lying on the ground, and migrated—taking several weeks over the "removal"—to build a nest under the excellent shelter it gave.

These are the chief instances of what might be claimed as intelligent improvement on instinctive action in the ant-world. Wasmann, of course, does not in the least admit intelligence in the cases observed by him. The behaviour was, he says, due merely to "an association of sensible representa-

* "Open Court," vol. xiv. p. 46.

tions and impulses." Bethe goes further than this somewhat ambiguous psychology, and affirms that the ants are the most elaborate neural mechanisms in nature, and nothing more. Certainly the application of the accepted test of intelligence has been singularly unsuccessful—singularly, because one would expect a far greater plasticity in such advanced insects. One is tempted to think that, in the case of the ant, selection has carried to its height the potentiality of rigid mechanism, leaving plasticity to other animal groups. Beside the overwhelming indications of purely instinctive action, and the many experimental proofs of lack of intelligence, these few instances are meagre and unconvincing; and it must be remembered that no animal has been more assiduously observed than the ant. The cases I have quoted are not at all beyond the range of unconscious association.

It is interesting to see that in the case of the ant some writers seem reluctant to admit the full consequences of their usual test of intelligence. Forel, we saw, frankly admits that ants are "very stupid" in their non-instinctive actions, and generally places their intelligence in the more impressive of their normal actions. If we apply strictly the accepted test of intelligence, this is quite inadmissible; but Principal Lloyd Morgan, for instance, who confesses that "there is a tendency to ascribe the behaviour of insects entirely to instinct" (p. 123), is unwilling to grant the consequence. He almost speaks with a disdain that is foreign to him of the idea that these wonderful co-operative commonwealths may be the sheer outcome of unconscious selection. As, however, no writer in our literature has so strictly defined the limits of instinct and intelligence, and insisted that no amount of precision, prevision, or complexity will suffice to place an habitual action beyond the range of non-intelligent instinct, it is difficult to follow him. The world of the ant and the bee is a world of such predominantly fixed and unvarying conduct that Maeterlinck has read into it a mystical theory of a blind impelling fate. Such few deviations as we do find from the instinctive habits of a species seem to fall well within that province of unconscious associative processes which, as I pointed out, lies, in our own experience no less than in theory, between instinct and intelligence.

Nor can we affect to be surprised that, in the insect world, selection has brought about such marvellous results, so plainly simulating intelligence. Wonderful as are the adaptations of the parasitic worms, they are far surpassed by the obviously unconscious adaptations of the insect world. The pupa-sleep itself, screening the animal in a time of transition when its changing organs would unfit it to struggle, is still mysterious. The infinitely varied defences which the grub prepares for its coming state of helplessness, and the adaptation of its nest (as in the male stag-beetle) to a form of which it can have not the faintest prevision, are as perfect a simulation of intelligence as the posting of sentinels or the ventilation of an ant-nest; yet the processes are the outcome of unconscious evolution, whether conceived on Lamarckian, Weismannist, or Mendelian lines. Not less instructive are the hiding of eggs and the provision of food entirely different from that of the insect itself, for young that the mother will never know; and the extraordinary devices of coloration, mimicry, and provision of special organs for special phases of the insect's career.

The instinctive activities of the wasp, bee, and ant fall into the same wide category of evolved mechanisms. And when we contemplate the vastness of the insect kingdom, we are little surprised that selection has attained such results in it. They form 250,000 species of the known zoological world, and it is suspected that they really number between one and two million living species. They made their first appearance, on the most moderate estimate, twenty million years ago, and have lived through all the vast and stimulating changes of the earth. The Carboniferous insects were tried and differentiated in the enormous changes of climate and vegetation of the Permian revolution. Soon after that, the highest orders appear. The Mesozoic insects were tried and differentiated in the equally great changes of climate and vegetation of the Cretaceous revolution. As a result we find them in the early Tertiary more numerous than they are to-day. Since then they have, in the north, passed through the climatic revolution at the end of the Tertiary.

It is not improbable that the secret of the extraordinary insect devices for securing the survival of the species lies in the supervention of these periods of cold. We have no trace of a winter season before the end of the Carboniferous. As the temperature rose again in the Mesozoic, and we have no deciduous trees until the Cretaceous, most geologists conclude that there was no marked winter season over the earth until then. Up to that time, we may assume, the insect mother was not regularly killed off before her eggs were hatched.* The great change fell on the insect world, as it had once done on the reptiles. From its countless and fertile species the quickened agencies of evolution selected the variations which tended most to preserve the progeny. The highest activities of the ant and the bee, it must be remembered, aim essentially at the preservation of the species. It is one of their profound differences from the activity of a human community.

On some such lines, and by discovering new species which may fill in the gaps of the existing graduated forms, we may one day arrive at a fair interpretation of insect life. It is far more promising than the mystic "instinct" which, being blind, was credited with the most marvellous prevision and precision. The task is already in hand, but there

* Professor Thompson ("Study of Animal Life"), commenting on the *Sphex* wasp, conjectures that there may have been a time when the mother lived to see its young. I submit that the geological record provides such a time.

is not space here to summarise the various suggestions as to the evolution of particular instinctive practices in the ant and bee worlds.

To the suggestion that here and there—in a few meagre instances—there is a departure from instinctive action and a beginning of conscious or intelligent action, I have replied, firstly, that we have not clear evidence in any case of the entirely novel and individual nature of the incident, and secondly, that there is a broad margin of "unconscious thought" between instinct and intelligence which has been overlooked. The question remains whether the cerebral activities of the ant or the bee may not be accompanied with a dull glow of consciousness. As I said in regard to the fish and the reptile, the problem seems to be as yet insoluble. External manifestations—of emotion, for instance—are, as we saw, misleading. I do not stress the well-known stolidity of the bee, to which one might oppose the ant's care of the maimed, nor the fact that a wasp will plainly continue its feeding if you snip off half its body with scissors. It is enough to say that all external manifestations are due to nervous disturbances, and do not *in themselves* indicate states of consciousness.

The problem will occupy us more fully later. The only reliable (and still indirect) way to infer consciousness is from the structure of the brain, and the brain of the insect is so obscure, and so little analogous to that of man, that we can draw no confident conclusion. There is a large cortical area in the brain of the female worker, but—to judge from Forel's fine drawings—it is impossible to compare it profitably with the human cortex. It is little use indulging in such speculation until we have more knowledge of the relation of consciousness to our own cortex, and considerably more knowledge of the obscure invertebrate brain. When we come to the bird and mammal we shall be less impotent.

A word must be said in conclusion on the other important branch of the Tracheates, the spiders. Their activities are so closely parallel to those of the higher insects that we need not linger over them. There is even less claim in their case for intelligent departure from inherited standards than in the case of the ant, and their habitual practices, however admirable, elude all scientific test of mind. "All the more remarkable and apparently intelligent actions of these creatures," says a leading authority, "seem to be done in obedience to a blind instinct, which is obeyed even when there is no longer any object to be served."* The apparent ingenuity with which the spider will stand "on tip-toe" on the top of a rail, and let the wind carry its silken thread to a distant anchorage, is of this order. The curious device of the trap-door spider, in making a hinged door, with bevelled edge, to its nest, is equally unconnected with intelligence. Moggridge found that if you removed the leaves or moss which the spider puts over the door to conceal it, and then strip bare the surrounding patch, the spider will

* "Camb. Nat. Hist.," iv. 377.

again cover the nest with green-stuff, and so make it particularly conspicuous. The diving bell of the water-spider is an evolved practice of the same character.

The principal study of the psychic life of the spider, by Dahl, resulted in very scanty evidence, though the author optimistically concluded that the spider has a "faint intelligence."* Most of the animal's activities proved to be plainly mechanical, and it was found to have a very short memory. The one chief instance, in fact, in which Dahl claims intelligence, or learning from experience, is of a character that we have repeatedly analysed, and not at all impressive. Dahl offered to a spider a fly that had been dipped in turpentine. It darted on the fly, and then shrank back, and for some time would not touch a fly of the same type. It is a simple instance of the kind of new nervous association, inhibiting the normal impulse, which Mr. Hobhouse suggests in the case of the tamed snake. The recorded cases of taming spiders come under the same explanation.

The spider's repute for intelligence has rested entirely on its remarkable instinctive performances. Modern science entirely rejects that interpretation, and the new test has failed to restore the spider's repute. We have no clear or cogent indication of conscious states in the whole invertebrate world, or

* "Versuch einer Darstellung der psychischen Vorgänge in den Spinnen," *Vierteljahrschrift für wiss. Philosophie*, Bd. x., pp. 84 and 162.

in any type of animal that lived before the Permian revolution in the earth's story. I have no theoretical object whatever in questioning the existence of conscious states in the higher insects. It will be found that a detection of consciousness in them would be in entire accord with such suggestions as I may offer. But the evidence as yet put before us is very far from convincing, and, in the very proper attempt to interpret their activities on the analogy of our own, a most important part of our own experience has been generally overlooked. We must, therefore, leave it an open question whether their neural processes have any accompanying consciousness. The solution depends on the progress of cerebral anatomy.

CHAPTER VIII

MIND IN THE BIRD

If the view of higher insect activity, which is suggested in the preceding chapter be correct, we can very well understand the association of so many proofs of individual unintelligence, and so few and questionable indications of intelligence, with those remarkable habits that have impressed the unscientific imagination for thousands of years. Evolution of nerve assumed two different forms in the later phase of terrestrial development. Just as, when the Mammals developed, selection promoted the growth of arms and armour in one group, speed and flight in another, burrowing in a third, and tree-climbing in a fourth, so there seem to be two ways of developing the animal's power of adjustment of behaviour to surroundings.

In the insect world the device favoured is a rigid and invariable mechanism—invariable within the limits of temperament, as we find even in metallic machines—for provoking long and complex series of purposive actions on a given stimulus of smell, or touch, or other sensitive area. The truest analogy to the ant-state or bee-state is not in the mental region at all, but in the human body. Those who profess inability to regard the complex social life of the higher insects as automatic, do not seem to reflect on what evolution has accomplished in the wonderful cell-state of the human frame. The extraordinary specialisation of, and division of labour among, the cells of the body are just as impressive as the features of ant-life. In that great republic we have a hundred castes of workers, each blindly accomplishing its share of the harmonious work, and with a great power of adaptation to special uses and environments. Recent research has even shown that the community has its armies of leucocyte warriors, ready to gather at any point in resistance to invasion. In precision of action, in simulation of prevision and intelligence, in complexity of structure and function, the one community is as wonderful as the other.

We now turn to the other mode of neural or cerebral development which was followed at least in the mammal world. The contrast must not be pushed too far, but it is useful to reflect that an animal is not necessarily approaching the sphere of consciousness because its nervous system, and its consequent behaviour, are increasing in complexity. Roughly, it is a contrast of rigidity of associations and plasticity of associations. Not that we begin to trace such superior plasticity from the beginning of the Mesozoic age, in the earliest birds and mammals. Very far from it, to judge by their nearest living representatives. But we do ultimately find a very different behaviour, superseding the rigidity of instinct, in the mammal; and we have to see how it develops, and how far it is found in the sister kingdom of the birds.

That the two classes are closely connected at their root is now well known. Both developed from the Permian reptile, the descendant of the Carboniferous salamander. This is now a commonplace of zoology and paleontology. It is more material to point out how the rise of these higher types is illustrated by the general story of the earth.

We saw that the reptiles which appeared toward the close of the coal-forest period were of two chief types. Had the great cold, which set in, lasted, there would have been no "age of reptiles." But the cold of the Permian was moderated, and great reptiles, thriving on the semi-tropical vegetation, carelessly leaving their eggs to be hatched in the warm sun, lorded it over the earth for two or three million years.

Meantime the supervening cold had developed a new type, or two new types, of animals. The first bird as yet discovered belongs to the Jurassic; the first mammals to the end of the Permian, or beginning of the Triassic. We need not rely on geological speculations in attributing their birth to the supervening cold. Any zoologist would pronounce, independently of the geological record, that the substitution of feathers or fur for scales, the development of a four-chambered heart, and the new care of the young, mean special adaptation to a colder environment. Nevertheless, all controversy as to climate apart, it is true that the Carboniferous temperature was high, and the Permian very much lower, and that glaciated regions now appear. We shall see that these regions are in a line with the great southern continent, and that the mammal is generally believed to have originated on that continent. In sum, the changes in the evolution of the planet itself are directly responsible for another momentous development in the story of life. The development of the heart alone is a great step. The complete separation of venous and oxidised blood henceforward must react on the brain. The closer link between mother and offspring is even more important.

However, the period of reaction on which the earth entered in the Mesozoic age kept mammal development back, as we shall see. The Tertiary period, coming after another of those prolonged changes which one may, from the biological point of view, call revolutions, will be the "age of birds and mammals." Meantime, the earlier forms were slowly developing. The first fossil bird, about the size of a crow, the now well-known *Archeopteryx*, is found in the upper Jurassic rocks of Bavaria. How—with its teeth, its claws on the front limbs, and its long vertebrated tail—it combines reptilian features with those of the bird, is familiar enough. The next specimens found (*Hesperornis* and *Ichthyornis*, of the Cretaceous) still retain the teeth of their ancestors, and lead on to the later birds. As some of the early deinosaur reptiles are small, and have hollow bones, it is supposed that the birds were developed from these, or from a common ancestor with them. A leaping reptile of that character would lend itself to the evolutionary theory. In the Tertiary we get parrots, swallows, owls, eagles, pelicans, and other modern types.

The bird, therefore, comes after the Permian revolution, develops slowly in the few million years of the Mesozoic reaction, and then differentiates with great vigour (like the mammal) in the Tertiary. We cannot assume that the earth was, after the Permian, as uniformly warm as before. Beyond question, a very large part of what is now temperate Europe, from England to the Jura mountains, was, in the middle of the Mesozoic, a warm, clear ocean, its floor studded with coral reefs. The vegetation is mixed. The Carboniferous luxuriance is gone, and conifer trees and cycads are plentiful. There seem to have been marked zones of climate, and the bird, if not differentiated in the Permian, must have been developed in one of the colder regions.

The infrequency and insignificance of mammal and bird remains until the Tertiary suggest that these more progressive types had not, to any great extent, the kind of environment in which their special features would give them a clear advantage until the end of the Chalk period. At the end of the Jurassic a fresh mountain-chain arises in America (the Sierras), and at the end of the Chalk period we have a vast and disturbing rise. The Andes and Rockies emerge in America: the Pyrenees and early Alps in

Europe. The vegetation develops rapidly in the changing conditions. Deciduous trees appear for the first time, and grass begins to cover the immense prairies. The climate is no longer suited to a race that leaves its eggs to be hatched in the sun, and the surviving reptiles retreat to the south. The advantage is with the organisms that build nests and hatch their young, or hatch the eggs within their own warm bodies, and then suckle the young; organisms whose blood does not rise and fall with the surrounding temperature, because they have a four-chambered heart: organisms that are wrapped in warm coats of feathers or fur, to preserve this new internal heat. The rise of the higher types is a necessary outcome of the earth's own development. And the link which will henceforward bind the parents to their helpless young will prove one of the most far-reaching innovations in terrestrial life.

Instead of attempting to follow the successive development of the various orders of birds, we may at once approach the question of mind in the birds of to-day. But it is advisable, in order to avoid a wearisome repetition of previous discussions, to premise a few words on the tests we may apply to them. The bird has been acutely studied on the accepted test of learning by experience, especially by Thorndike and Lloyd Morgan. If we decline to accept that test as decisive, how can we appreciate its activities?

The point may be well illustrated by an incident which falls within my own experience, and is a particularly striking case of modifying instinctive behaviour on the ground of individual experience. Some years ago I was walking by the lake in the park of the Ctesse. de Meeus, near Brussels, when I noticed that a swan, from fifty to a hundred yards across the water, was hurriedly making for me. Its intentions were so patent when it reached the shore, and darted up the bank, that—I fled. At that time I wore the costume, and had the shaven poll and sandalled feet of a Franciscan friar, and the explanation given me by those who were in a position to know was no hearsay, or guess. It appeared that some time previously a friar, fishing in the lake, had been responsible for the death of the swan's consort. Ever afterwards the widowed swan made a ferocious attack on any brown friar who passed the lake from the neighbouring monastery, and on no other person but a friar.

It is impossible to credit so prosaic a bird with an elaborate act of reasoning, but the incident offers as clear a case of action on individual experience as can be found. We shall see that most of the claims of bird intelligence rest on a similar ground. Since the criterion seems inadmissible, it is necessary to say at once if, and how, we may detect in the bird and mammal, at least, a beginning of the consciousness which we shall presently find highly developed in man.

As will be gathered from the preceding chapters, what I especially demur to is the search for "memory," "emotion," and "intelligence." We have seen that there are not only theoretically, but in our own experience, unconscious nerve-processes which may very well account for the animal activities to which these descriptions are often applied. The recording, reviving, and associating of impressions may, in the animal as well as ourselves, be purely physical. We should find it exceedingly difficult to draw the line, if we suggested that simple processes of that order might be unconscious, but complex processes involved consciousness. Hardly any one will doubt that the rush, the apparent anger, and the beating of wings on the part of the swan, were due to the physical impression recorded in its brain after the death of its mate. In our own experience such physical impressions and resultant disturbances would have a conscious side. How can we be sure that this is the case with the bird?

I submit that the only way to come to any conclusion is to compare the organ of consciousness in ourselves with the presumed organ in the bird. Inferences from external manifestations are precarious. There is a fictitious appearance of robust common sense in the axiom that we must judge the animal as we judge our fellow man. On that test, however, the anger of a lobster, a pike, a spider, or an octopus will prove to be as intense a state of consciousness as the anger of a civilised human being, which is absurd. We may admit equal strength of nerve-storm, but the immense disproportion of cerebral machinery absolutely forbids us to grant any parity of consciousness. The only general conclusion we can reach is, therefore, that we must interpret the animal's behaviour in terms of its approach to, or remoteness from, our own type of nerve-structure. Emotion is the consciousness of the nerve-storm which existed long before the animal becomes conscious of it. Intelligence is the consciousness of the nerve-associations of stimuli which precede the development of consciousness; memory, the consciousness of recorded stimuli; will, the consciousness of outgoing nerve-impulses. Presentation, emotion, volition, and memory are at some point in the story of evolution irradiated by consciousness. What we want to know is, not when they appear, but when, and why, they are lifted into this higher region from the region of unconscious processes.

We have as yet found no confident reason to think consciousness has appeared, though we have left the difficult question open in some cases. We cannot say whether the analogy between the brain of the fish or the ant and the human brain is close enough to justify an inference. But we may now glance at the other end of the series. Consciousness is very highly developed in the lowest human beings, and it is agreed that, whatever its nature may be, this development is due to the enlargement and elaboration of the cortex. As this cortex is proportionately developed in the higher birds and mammals, we may legitimately argue from analogy that they have a measure of consciousness.

Legitimately, but with no pretence of precision, because our knowledge of the relation of consciousness to the brain is extremely slender. I make no attempt to define consciousness, partly because it defines itself more clearly than words can do, partly because all attempts to define it have proved abortive. In his summary treatise (*Contemporary Psychology*) Professor Villa tells us that in modern science consciousness is "the whole mass of psychical manifestations of the individual and of the species."

The definition covers under the word "psychical" its inability to do more than name the essential characteristic of these manifestations. Nor do psychologists of the more heterodox and adventurous schools take us much further, if at all. For Exner (*Entwurf zu einer physiologischen Erklärung der Psychischen Erscheinungen*) consciousness is "the group of presentations already in the cortex, into which a fresh presentation enters." For Le Dantec (*Traité de Biologie*) it is "d'être au courant de sa structure actuelle," or "the translation into a certain language of the actual structure of our body."

Unhappily, when we turn from the superfluous exercise of definition to the substantial task of determining the relation of consciousness to the brain, we are still seriously perplexed. Whether or no the optic thalami and the medulla be the centres of inhibition, as Exner claims, the cortex is the general seat of consciousness. But the vast cortical area is largely an unexplored region. Even if, as has been suggested (though again contested), the conjunction or contact of the fibrils of the cells means consciousness, and their disjunction unconsciousness, we are still at a loss to know why. Even if, as Romanes says, the function of the cerebral hemispheres is to deal with stimuli so varied that special reflex mechanisms have not yet been assigned to them, and that the perturbation of the cerebrum in dealing with them gives rise to consciousness, we are not far advanced in the problem.

All we know is that particular regions of the cortex are concerned in particular conscious functions.* Whether the brain of the vertebrate originates from the fusion of the anterior ganglia of an early arthropod ancestor, or more directly from the supraœsophageal ganglion of an annelid, it was at first a cluster of sense-motor centres. The eye-pits, the ears (or their analogue), the nasal pits, and the other sensitive areas at the surface, had their central bureaux, for transmitting the stimuli to appropriate muscles, and turning them into muscular language. These sense-motor areas have been recovered in the human cortex,† and form a ground-

* Loeb denies that the localisations in the cortex have been sustained, but Professor Sherrington ("The Integrative Action of the Nervous System," p. 272) records that he and Dr. Grünbaum verified the motor-localisations of Ferrier and Hitzig, and Dr. J. B. Johnston ("Nervous System of Vertebrates," p. 349) confirms the localisations of Flechsig. I follow especially the latter work (published 1907).

† See partial diagrams in Kirke's "Handbook of Physiology" (13th ed., p. 647), and Johnston or Sherrington, *op. cit.*

work of comparison between the brain of man and the brains of the lower mammals and birds.

On making that comparison it is found that the characteristic of higher development is the increasing growth of association-areas, between the sense-motor areas, in the cortex. Professor W. James had long insisted that the root and meaning of mental associations must be sought in the brain, and the progress of research confirms his anticipation. The study of the effect of experimental tampering with the various centres, the observation of the functional results of disease of different areas, the comparison of the immature brain of the embryo and the child, and the graduated study of mammal brains, are yielding fruit. The sense-motor areas come first: the association-areas gradually expand between them, and enlarge the surface of the cortex. In the lowest mammals and birds the sense-motor areas occupy nearly the whole cortex. Its growth, as we ascend the animal scale, is a growth of association-areas. Moreover, as the myelinisation of the fibres proceeds from the sense-motor areas to the associational, it seems that—as we would naturally expect—the latter were gradually differentiated from the former; and as the progress of myelinisation, from border to centre of the child's association-areas, corresponds to the increasing complexity of its mental operations, we are justified in regarding the borders as the seat of simple associations, and the centres as the seat of the highest associations.

One further point may be borrowed from recent cerebral science before we apply the knowledge. The anterior centres in the cortex are concerned with subjective states—the emotions and will. Lesion or disease of them leads to loss of the sense of personality, of values, and of confidence, and a lowering of the moral and æsthetic judgment. The middle zone is chiefly concerned with speech, and associated with hearing. The posterior areas receive impressions from the outer world, and associate them in ideas of objects and their relations. There is evidence, both in embryonic development and comparative anatomy, that the posterior areas are the oldest, and the anterior the most recent. This order corresponds to the development of psychic life. The brain is first a recorder and combiner of visual and olfactory stimuli. Hearing—which is still much disputed, and apparently very restricted, in the fish and the insect—is developed later as a definite means of communication. Lastly, a new (somæsthetic) area develops in front of the cerebrum, and human attributes come with it.

Why the higher, later, and anterior area begins to develop in the forerunners of man, we shall see later. For the moment we have only to see what basis there is for a comparison of the organ of mind in man and the bird and lower mammal. I need not say that I am not suggesting these facts as an explanation of consciousness. Nothing is gained by hiding with sonorous phrases the fact that consciousness is still a profound mystery: a fact that does not surprise those who know what exploration has still to be made in the region of the human cortex. We have but delimited broad areas of that region, as we have done in Central Africa, or some other region that teems with unappreciated details. But what has been done is extremely suggestive.

In the most primitive unicellular forms of life the whole body is sensitive to certain pulses of its environment. The primitive multicellular body also is at first only a colony of equally sensitive units, but in time, in the division of labour, some of the groups specialise on sensitiveness. As this process of specialisation continues, some of the cells respond to light only, some to air-pulses, others to water-movements, and others to finely divided particles of floating matter. We thus get the various sensory areas, and, as the animal body elongates, they find their place in its front part, or head. The next great advantage that selection can secure is a mechanism for associating the etheric and aerial impulses, and the impresses of other emanations from objects in the animal's surroundings.

At first this brain is a bureau for receiving the impulses gathered by eyes and nose, and transmitting them, generally through the medulla and cord, to the muscles of the body. With the growth of the association-fringes between the sense-motor centres, the animal gains in plasticity of adjustment. Its brain not only records the stimuli impressed on it, but is able to connect such recorded experience with a recurring experience; and this has the effect of inhibiting its impulse to act, when the revived association is disturbing, and of modifying its conduct on the basis of its received impressions. It learns by experience. Presently the sense of hearing is fully evolved, and a new source of world-impressions is provided. This alone must mean an important advance of psychic life; but when we find that it coincides with a further improvement in the eye, a richer supply of blood through the appearance of a four-chambered heart, and a prolonged and searching test of the animal's power of adjustment through immense changes in the environment, we have some substantial explanation of the qualities which lift the bird and the mammal above the rest of creation.

Our chief concern to trace the upward progress will be in connection with the mammal. In the case of the bird we will at once examine the results of research on the higher types, and be content with a proportional extension to the lower forms. The evidence we have to examine is of two kinds. Firstly, there is the anecdotal or observational evidence, chiefly collected by Romanes, which one must regard with some reserve; not only because it belongs to a time when discussion had not yet given a more precise value to psychological tests, but because it is frankly part of an effort to prove "reason" in lower animals, against the opponents of evolution. The second and more recent class of evidence is of an experimental and more critical nature. I take it chiefly from Dr. Thorndike and Principal Lloyd Morgan, both of whom have done valuable work, and who substantially agree in dissenting from Romanes.

For reasons which I have already given I leave out of account all the evidence for emotion in birds. Unquestionably, birds exhibit the same conduct which we ourselves do under the influence of anger, jealousy, pride, and sympathy. These movements, however, do not of themselves indicate consciousness, and can only be assumed to be conscious in proportion as we may independently find evidence of the existence of consciousness. The parental behaviour of a stickleback would, if we take such external indications too literally, grant it an absurd degree of consciousness.

For the same reason—that an unconscious nerve-process may suffice—I omit all consideration of memory in birds. Nor need we now linger over instinctive practices, however ingenious or adaptive. All the varied and wonderful phenomena of nesting and migration are now admitted to fall within this category, and belong to physiology rather than psychology. Of themselves they prove neither intelligence nor any other shade of consciousness. Romanes, of course, would not assent to this. After describing how blackbirds and thrushes will convey their snails to a considerable distance in order to break their shells against stones, and certain gulls and crows with break shell-fish by dropping them from a great height, he says: " Both these instincts manifest a high degree of intelligence, either on the part of the birds themselves or on that of their ancestors." As this theory of lapsed intelligence has fallen out of favour, we need not delay with it. There is no more ground for assuming it here than in the case of the tower-building rotifer, in which it would be palpably absurd.

Of the countless numbers of stories of parrot-intelligence, to which little serious notice is now paid, one only need be quoted. On the high authority of Mr. Venn, the famous logician, Romanes tells of a parrot which learned to imitate the bark of the dog when the servants' bell was rung. After a time it would bark in the absence of the dog, if the back-door bell were rung, not at the sound of the front-door bell. An observation of Mr. Venn's on this is worth quoting : "This is but a trifle in the way of intelligence, but it struck me as an interesting analogous case to a law of association often noticed by writers on human psychology." Precisely. It is a plain sensory association of a recorded with a recurrent stimulus, and there is no reason whatever to ascribe the discrimination between the two bells to "intelligence" rather than to the parrot's ear. The point we have to bear in mind is how far such associations may carry us in interpreting the animal's behaviour.

The cases of "unusually high intelligence" quoted by Romanes may be given summarily :—

(1) A tamed bull-finch, which is released every morning in the bedroom, pipes and bows to a painted

picture of a hen-finch, and is indifferent to its own image in the glass.

(2) Birds are often trained to perform in shows. So are fleas, as I have seen.

(3) Birds quickly learn to avoid telegraph wires in flying.

(4) An eagle submits quietly to surgical treatment for an injury.

(5) A robin, more or less attached to a gardener, calls his attention to a snake which threatens its nest.

(6) Some geese go regularly to the corn-market on market day, though it is only held once a fortnight. The noise does not attract them, as they go once when the fair is suspended.

(7) A pewit shows "considerable appreciation of mechanical appliances" by alighting directly on its nest, instead of running along the ground, as usual, when snares are laid round the nest.

(8) A pet jackdaw's daily bath is forgotten. He flies to the window, and goes through the mimic show of bathing.

(9) A pigeon flies at a horse's head, when the corn on the floor is all eaten, and causes the horse to spill more corn.

(10) Swallows are observed to stop up the nest stolen from them by sparrows.

(11) Crows steal a dog's bone by distracting its attention. One digs its beak in the dog's back, while the other snatches.

(12) Crows are often seen to hold trials for theft, and to punish the delinquents.

Modern writers generally decline to consider these anecdotes gathered from far and wide, and we may follow their example. In few cases is the observation quite reliable. In some cases a remark is naïvely added, to enhance the effect, which undoes the claim. In the case of the pigeon (9) it is added that the feat was "repeated many times." We at once see the possibility of a natural and fortuitous disturbance of the horse becoming a fixed and instinctive association with the shedding of corn. But in most cases the observers merely had the customary eye for "cleverness" in animals, and their stories are of doubtful value.

When we turn to the scientific observation and experiments that have been made on chickens, we at once see how the powers of the bird shrink on serious examination. The careful observations of Lloyd Morgan are directed rather to showing how far the actions of the young chick or duckling are instinctive. Pecking, swimming, &c., are instinctive, though at first imperfect, and this is not the place to inquire how far the bird learns from its mother, or imitates others. The point is disputed. But Lloyd Morgan finds at once a departure from instinct, and an indication of intelligence, in the modification of the chick's behaviour on the ground of its own experience. A chick pecks instinctively at desirable and undesirable things. When, however, it has once tasted a nasty grub, it avoids such things afterwards. To this we may add authentic instances of birds altering their behaviour in nesting or rearing young (as when a hen rears ducks) on the basis of an experience fresh to their species.

In judging such phenomena we must, as we have often seen, be very precise about our terms. Lloyd Morgan does not find any proof of "reason" in the bird, and does not ascribe intelligence to it in the popular sense (which is, indeed, psychologically inaccurate). He means simply that there is a conscious adjustment of behaviour to conditions on the ground of experience, but no abstract perception of means and end. The process is an association of concrete images. In birds, he says, "the association of ideas is strong, and is rapidly formed as the result of individual acquisitions." But how do we know that the process is one of association of conscious ideas, and not of unconscious nerve-processes? On what ground can we say that an inherited association of stimulus and impulse may be unconscious (say, at lower levels of life), but a fresh association *must* be conscious? It will appear presently that I have not the least desire to deny the bird consciousness. My only concern is about the tests of its presence.

The inquiry becomes still more interesting when we read Dr. Thorndike's results.* His experiments on cats and dogs will concern us later. As to birds, he enclosed chickens in boxes, and tested their capacity for finding the way out. It is enough to give his results. He found neither reason nor in-

* "Animal Intelligence." Supplement to the *Psychological Review*, June 1898.

telligence, but a fortuitous discovery of the way out, forming an association in the animal's brain which gradually prevails over its less successful impulses. The most interesting illustration is, perhaps, that of the chick which Dr. Thorndike released as soon as it pecked its feathers. After a time the chick would peck its feathers as soon as it was put in the box. Of the many and varied actions it performed on being enclosed, this one alone was connected with the satisfactory impression of release. The other impulses, therefore, were stamped out, and this one was selected.

It will be seen that this is the interpretation I have urged throughout. Lloyd Morgan says ("Animal Behaviour") that he substantially agrees with Dr. Thorndike, but he must surely have overlooked the passage in which Dr. Thorndike suggests that these animals (below the Primate level) have "no images or memories at all, and no ideas to associate." The truth is, however, that Dr. Thorndike shows less than his usual lucidity on this point. He throughout assumes that the animal is conscious of its nerve-processes, and in that case one seems justified in granting it "images" or "ideas," of a rudimentary character. Further, it is difficult to see how we can deny the chick the "memory" of pleasure, when Dr. Thorndike says that the particular impulse is associated with the actual sense-impression by "sequent pleasure." It is surely the memory of the former pleasure, which followed the impulse. In this sense Lloyd Morgan may fitly say that he agrees with Thorndike's refusal to see "reason" in the bird's behaviour; though he makes a reserve as to whether there may not be some (as yet unproved) "beginning of a rational scheme" in animals below the Primate level. Mr. Hobhouse—who has, however, made no experiments on birds, and pays little attention to them—is more strongly opposed to Thorndike's conclusions, as we shall see.

We have this result, then, in regard to the psychic powers of the bird. On the one hand, the countless anecdotes which imply reasoning in the bird are neglected as unsuitable material for sober analysis by recent students. On the other hand, we have definite and enlightened experiments which show that the bird does enlarge on its hereditary stock, and adapt its behaviour to special surroundings; but that this adaptation consists in the association of sensory impressions and impulses, and that the association is due to the natural selection of one impulse (out of many) which chances to obtain a pleasant result. I submit that in this we have an intelligible extension of the nerve-process of which I have traced the evolution. In the lower animals with distinct senses, the brain is a collection of meagrely connected receiving centres. In the fish the centres come closer together; closer still in the reptile; in the bird the cerebral cortex develops strongly as a single organ, with separate areas of sense-motor action, intimately connected by the interwoven neurons of the association areas. The sense of sight, in particular, is finely developed in the bird, and this alone must mean a great advance in adaptability to surroundings. But the growth of the cortex also means a growth of the association-areas, and this explains the beginning of superior plasticity.

This does not mean, however, that we may regard the bird as merely a more advanced automaton, and say that the theory of consciousness is superfluous. We saw that there are two ways of inferring the presence of consciousness. One is to adopt the metaphysical saying, *Ex nihilo nihil*, and say that consciousness, or some rudiment of it, is present from the beginning of life. The other is to judge the animal as we judge our fellow-men. I have adopted the latter test—with a modification. The lower animals are so widely removed from us in organisation that, even if they seem to act as we would, we must take account of the differences of structure. Moreover, we have in us a standard of unconscious, as well as conscious, action by which to judge them.

Seeing, then, that we form both conscious and unconscious associations, that, as Weismann says, "intelligence" may be unconscious, and that even our conscious processes of association have corresponding nerve-processes, we cannot infer that the animal is conscious because it forms a new association. We can but make a vague inference as to the presence of consciousness from the presence of its organ. The anger of the turkey or the robin may, as far as external indications go, no more indicate consciousness than the tears and moans of an unconscious patient in the dentist's chair. But the bird has, in moderate development, what we know to be the organ of consciousness in man. The cerebral hemispheres have at last gained conspicuously on the other parts of the brain. We seem to be justified, therefore, in ascribing to it some unknown degree of consciousness of its nerve-processes, but until the anatomy and histology of the brain are very much further advanced we must be content with this vague deduction.

Other aspects of this appearance of consciousness in the evolution of life will be discussed at the close of the next chapter. We have seen that Dr. Thorndike draws an important line at the Primates, and other authorities find there a new departure, if they draw a less rigid line. At all events, we may discuss the rise and development of the lower Mammals before we analyse the stage we have reached, in preparation for the higher and final stage.

CHAPTER IX

THE GROWTH OF THE MAMMAL BRAIN

WE return, therefore, to the point in the story of terrestrial development when the Coal-forests and the Permian revolution have prepared the planet for a new race of organisms. The most extensive uplift of the crust that is known in the geological chronicle has transformed the vast swamps into firm continents. The sunlight falls through a clear, cold, dry atmosphere on a new earth. The luxurious lepidodendra and sigillariæ wither away, and hardy conifers spread into the valleys from their native hills. The floundering salamanders abandon the water, and, as reptiles, travel on firmer limbs over the landscape. Then the crust slowly sinks again, the ice-fields melt away, the tree-ferns spread once more, and the great reptiles enter on their golden age.

But here and there in the strata of the crust which represent the succeeding Triassic and Jurassic periods, we find, amidst the giant forms, the remains of certain small animals of a new type. The passage from the reptile to the mammal is even plainer than the evolution of the bird. "In the Triassic period," says Dr. Woodward, "the Theriodont Reptiles so closely approached the lowest mammals that skeletons alone hardly suffice for the exact determination of their affinities." These mammal-like Reptiles are found largely in the Permian and Triassic of South Africa, and the earliest definite mammals are found in the Triassic of Germany and England, and the Jurassic of the United States. The remains suggest that a primitive reptile of the great southern continent gave birth to the mammal during the cold of the Permian and early Triassic period, and the new race wandered north as the temperature rose again. Whether the Theriodonts are intermediate, or a side issue, is not certain.

Most of these remains are teeth and jaws, and we find similar teeth in the young duck-mole (*Ornithorhyncus*) of Tasmania. Australasia is a fragment of the great southern continent, fortunately cut off at an early date, and so preserving a primitive fauna of a most instructive character. No revolutions, no irruptions of higher types, have disturbed the conservatism of its animal population. Australia and New Zealand were, until man invaded them, living pages preserved from the Middle Ages of the chronicle of life. Allowing for later possible modification of snout and extremities, therefore, we have in the duck-mole a survivor of the first race of mammals. It is an egg-laying mammal, with one common outlet for its excrements, and other reptilian features. Another Monotreme, the spiny ant-eater, with a related form in New Guinea, is the only other survivor. Their apparatus for suckling the young, when they have hatched their eggs, is a primitive organ: a series of perforations in the breast, through which the fat (milk) oozes from the mother's blood, to be licked by the young.

The next group of mammals, in ascending order, the Marsupials, is also strongly represented in Australia (and Tasmania and South America). These pouched animals, now represented by the kangaroo, opossum, &c., are not only the next successors to, though not necessarily the direct descendants of, the Monotremes, but the only other type of mammal known until the Tertiary period. "It seems likely," says Dr. Woodward, "that the Australian region has remained isolated from the rest of the world since the end of the Secondary epoch, and that its marsupials are the slightly altered survivors of the mammal-life then characteristic of every continent. The only known mammals of the Secondary or Mesozoic epoch are creatures about as large as rats, whose jaws and limb-bones have been found in the Upper Cretaceous and Jurassic rocks of North America, and in the Jurassic of England. Most of them seem to have been insectivorous marsupials."*

The indications are, therefore, entirely in accord with the general principles already suggested. After the cold of the Permian we get a race of fur-clothed animals, with warm blood, and a practice of either hatching the egg or developing it in the body, and then suckling the young. These are destined to

* "Guide to the Fossil Mammals and Birds" (1904), p. 80.

oust all competitors in the conditions which suit them, but the temperature rises again. They wander northward, and remain insignificant in size, and unprogressive, while the golden age of the reptiles lasts. In those hard conditions, with no special advantage from their warmer organisation, and so frail a defence against the carnivorous flying and leaping reptiles, their little superiority of brain would tend to be selected. Possibly they kept to cooler regions than the reptiles, but their insect-diet would limit this tendency.

The mental life of the Monotremes and Marsupials has been so little studied from the more exacting modern point of view that we are unable to trace with any confidence the advance of mind in them. The Monotreme must, in fact, be left out of account; and indeed we have few safe traces of it in the Mesozoic. The Marsupial is more familiar, but we must not hastily conclude that whatever mental faculty there may be in the modern marsupial may be transferred to its Mesozoic relatives. In most of the higher animal groups brain has advanced in the Tertiary and Quaternary. In any case the marsupial has not attracted attention from our point of view. Americans speak of the cuteness of the opossum, but the repute is grounded on its instinctive habits, such as shamming death and evading pursuit. The kangaroo, on the other hand, is proverbially stupid. As the cortex is growing appreciably in the marsupial, a close examination of its behaviour and comparison of its cortical areas with those of man might prove of great interest, but the materials are not as yet available.

It is more profitable to pass at once to the consideration of the fresh terrestrial revolution, which at length inaugurates the age of mind. We saw that this second revolution begins in America with the rise of the Sierras at the end of the Jurassic; the work was to be completed at the end of the Chalk period with the rise of the mighty chain of the Rocky Mountains and the Andes. The temperature sinks to some 6 or 7 degrees above the actual temperature. The oak, maple, willow, beech, poplar, walnut, and large numbers of our familiar trees appear, and the annual shedding of their leaves gives us our first indication of a definite winter season. Grasses also begin to carpet the plains, and provide a new diet. In Europe, though somewhat later, there is a corresponding upheaval. The Pyrenees and earlier Alps rise into the colder air, and the continent gradually emerges again from the Cretaceous ocean.

The living inhabitants of the earth again felt the profound influence of its movements. Even in the ocean, where the great Cephalopods run into eccentric forms, like an expiring race, the revolution is felt. On the land the change proved most momentous. The giant reptiles slowly pass away, or slink to the tropics, as the Cretaceous advances. The new continents, in the new temperate zone, offer a magnificent field for the mammals. The obscure and insignificant insect-eaters of the long Mesozoic age become the ruling dynasty, and differentiate with great vigour and rapidity. The new grasses and trees afford them a rich diet, and the gigantic herbivores that now develop bring in their train an equally powerful race of carnivores. The mechanism for feeding the embryo within the mother's body —the placenta—assumes a more effective form. The mammals multiply with the utmost rapidity, and selection begins to direct the countless variations into the forms with which we are familiar.

The mammal remains of the early Tertiary are of a very generalised character. Features that are now distributed amongst widely distant groups were then united in ancestral types, just as the features of divergent Aryan languages are more or less united in the more primitive Sanscrit. We have vague suggestions of the horse, the elephant, the rhinoceros, the deer, and other forms, curiously mingled in these ancient skeletons. All are five-toed, and the older they are, the nearer they approach each other.

Within the few hundred thousand years of the Eocene period they differentiate rapidly, and our familiar types begin to appear—the elephant, horse, rhinoceros, hog, camel, ox, sheep, antelope, ape, tiger, whale, &c. In the increasing pressure on the swarming continents, and especially in the stress of constant migrations, the generic types are quickly outlined. Some return to the ocean of their remote ancestors (whales, seals, &c.); some mount into the air, like the birds; some burrow in the earth; some ascend the trees; some develop speed of limb and acuteness of sense; some rely on bulk, others on horns, others on teeth and claws, others on armour-plating. Limbs and bodies are moulded in endless ways in the different special environments. In the words of Lapparent:

> "The mammals, so long atrophied, develop with extraordinary vigour, and take possession of the globe; undoubtedly because the change that has occurred in the distribution of heat, while it was fatal to the reptiles, has at last given warm-blooded animals a chance to manifest all their superiority."*

It would be out of place here to follow the evolution of our familiar types out of the generalised forms of the early Tertiary. The development of the horse is well known, and the recent reconstruction of the genealogy of the elephant, and similar achievements, do not fall within our sphere. It is enough to indicate the general principles which explain the advance of life in the Tertiary. Once more a planetary movement has reacted profoundly on the procession of life. The slow convulsive movement of the crust has, directly and indirectly, quickened the evolution of its mantle of vegetation, and altered the thermal conditions of life. The rise of the mammal, with its larger brain, is an inevitable

* *Géologie*, p. 1481. The four-chambered heart does not, of course, suddenly appear in nature. The reptile heart has three chambers, and an imperfect partition in the ventricle. The crocodile has four chambers, but a different system of arteries.

consequence. The fish had a brain of the proportion, by weight, of 1 in 5668 to the weight of the body. The terrestrial movements led to the appearance of the reptile, with a brain of 1 in 1321. The next great physical revolution brought on the bird and mammal, with the respective proportions of 1 in 212 and 1 in 186.*

Let us now take the results of experiment and observation on existing mammals, and we may in the end supplement the study with a few evolutionary observations. In this case I propose to take first the recent results of experiment, and then see if there are reliable observations which compel or permit us to enlarge the results.

Dr. Thorndike subjected cats and dogs to the same experiences as the chicks I have described. The idea was to enclose them in boxes which could be opened from within by some other than quite obvious means—the pulling of a string, or pushing of a bolt or lever, &c.—and observe their efforts to escape. Cats were more successful than chicks, and dogs than cats, but Dr. Thorndike concluded, as before, that they had no intelligence, reason, memory or ideas. "Till the Primates," he says, "we get practically nothing but instincts and individual acquirement through impulsive trial and error" (p. 63).

* We shall see that this proportion of weight of brain to body must only be taken as significant for large classes. So intelligent an animal as the elephant has the proportion of 1 in 500, while the unintelligent canary shows 1 in 14.

His theory, in fact, is the same as that which I have proposed in the earlier chapters, though I had reserved the reading of his essay until about to write this section of my work. The animal being placed in a new situation, especially one of an unpleasant nature, receives other than its normal stimuli. It responds with a number of erratic movements, each of which is aimless, though we may regard the tendency so to respond as a purposive and useful tendency. One of these movements—say, the chance pulling of the string attached to the door—is followed by the pleasant effect of release. When the animal is again enclosed, this association is still feeble, but it exists, and the act "occurs" to the animal more quickly. On repeated experiments the association becomes stronger. The impulse to pull the string is "selected by success," and the other random impulses disappear. Dr. Thorndike gives the time-curve which shows in each case the gradual elimination of the useless movements and predominance of the right movement. He is convinced that in no case was there a deliberate or "conceptional" application of means to end, but only the natural selection of a fortuitous movement. Mr. Hobhouse questions if the time-curves given show this in every case, but, if we allow for differences of temperament and chance, they seem to have that complexion.

Lloyd Morgan, as we saw, assents to the conclusion generally. The positive evidence as yet before us shows "intelligence," but not "reason," in the non-human mammal. The intelligent being "forms sensory impressions and sensory images linked together by bonds of association." It rises above the merely instinctive animal by forming these associations on the ground of its own experience. The rational being, on the other hand, "fixes his attention on the way in which the elements of the situation are connected and related." This is not what the cat or dog does. It does not perceive the relation of the string and release. It impulsively pulls the string, after practice, because the associated idea of release arises in it. But Lloyd Morgan adds that he is not prepared to deny dogmatically that there may be "the beginnings of a rational scheme" in such animals.

Mr. Hobhouse conducted a series of experiments, similar to those of Thorndike, on cats, dogs, otters, elephants, and apes. In principle, the aim is the same. The animal must perform a specific action—pull a string, loop, or bolt, upset a jug, &c.—to obtain relief or to secure a piece of food. In the detailed descriptions of the experiments one cannot see much, if any, divergence from those of Thorndike, yet Hobhouse expresses his conclusions in terms strictly opposed to those of the American experimenter. He maintains that chance has little to do with their success, and that the animals generally "are aware what they are about." He does not, however, grant them reason, or abstract ideas, or a distinct perception of relations between objects. They do not perceive "comparatively distinct elements in a comparatively distinct relation," as the ape and the man will.

Of the three positions that of Principal Lloyd Morgan will probably commend itself to most people. Dr. Thorndike somewhat perplexes us by denying memory and ideas, yet admitting consciousness; and the original scheme of psychic evolution which he suggests needs fuller and clearer presentation before one can follow it. Mr. Hobhouse, on the other hand, perplexes us with his claim that the animals are "aware what they are about," yet do not appreciate the relations of things. In a sense, both sets of experiments are misleading. Dr. Zell has pointed out that, as the dog's predominant means of adjustment to surroundings is its sense of smell, these experiments are unfair in that they throw the burden wholly on sight or touch. I would suggest that Mr. Hobhouse's experiments are misleading in another way. He is impressed by the "awareness" and "attention" of his cat and dog. But we have trained our domestic animals abnormally in this respect, and a course of experiments, like those of Mr. Hobhouse, which generally ended in a reward, would tend greatly to engender this attitude in them. Let us conclude that experiment has only shown associations of impressions and impulses in the non-Primate mammals, and that the size and structure of their brains make it probable that these associations are consciously felt.

We may next consider Lloyd Morgan's suggestion that there may be the beginning of rational action in the lower mammal. Here an appalling literature of anecdotes awaits us, and we have to proceed with caution. The vast majority of the stories are inspired by that vague admiration of supposed cleverness which gives us, for instance, the fact of a pigeon distracting a horse, to make it shed corn, as an act of reasoning. The habit may have begun just as fortuitously as the pulling of a string in Thorndike's experiments. What we now seek is definite proof that the animal expressly sees the relation of means to end, and has, consequently, abstract perception.

The worthlessness of so many of these anecdotes is easily illustrated. Mr. Hobhouse mentions an elephant in Belle Vue Gardens which used to take pennies from spectators, and put them in an automatic machine which yielded gingerbread. I happen to remember the animal well, and often joined in the admiration of its sagacity when it scornfully refused half-pennies. But Mr. Hobhouse learned from the keeper that months of training had been required in order to teach it to discriminate between pennies and half-pennies. Another is found in Lloyd Morgan. His dog used to let itself out at the gate by lifting the latch with its head. A stranger would from this gather an impression of great sagacity, but Lloyd Morgan chanced to have seen how the habit began. It was done at first by accident, as the dog poked its head between the bars, and the action was gradually "selected" in the way described by Mr. Thorndike.

Here, at once, is a possible key to the innumerable cases of animals opening gates, knocking at doors, and so on. I had a cat at one time which used to rattle the loose cover over the key-hole when it wanted the door opened. The habit clearly began from noticing the accidental rattle of the cover when one went to the handle, and the success of the act fixed it.

Lloyd Morgan further experimented on making a dog convey a stick through bars, and found no deliberate adjustment at all. In a dog learning to wait for a ball rebounding from a wall, instead of rushing straight after it, he likewise found no logical inference. The latter experience may throw some light on a story told by Dr. Andrew Wilson, and pressed by Romanes. A dog which used to chase a rabbit until it found shelter in a drain, was noticed after a time to rush straight to the drain, instead of making the longer tour. In the familiar group of impressions—rabbit, path, and drain—the different association of direct path and drain might well arise. The dog had learned to regard the drain as its objective as well as the rabbit. The association is more complex than those we have analysed; but the dog's cortex is far more developed than that of any other animal we have examined. Progress, both Thorndike and Lloyd Morgan say, consists in the freeing or loosening of the elements of association. We evidently have the beginning of this process in the dog; and it corresponds entirely to the growth of the association-areas in its cortex.

This is still further seen in another dog-story which we have on the good authority of Lloyd Morgan. I see no special significance in the fact that, on climbing a steep hill and being compelled to lift his dogs up certain ledges, they, after the first ascent, waited at these spots to be lifted. It is an exceptionally rapid association, but it is not clear how far the nature of the locality helped them. More important is the story of a terrier which was permitted in a dining-hall, and for which the door was usually opened when it sought exit with a bone in its mouth. It disdained bread. One evening dogs were heard barking outside. The terrier had no bone, but it at once snapped up a piece of bread, and made for the door. When the door was opened, it dropped the bread and ran out to join its fellows.

This is as instructive a story as we have, and rests on the highest authority. Mr. Hobhouse says that any application of the association-theory will prove very cumbrous. This may be the case, if we take the association-theory in a rigid sense, and deny that there is any loosening of the elements below the Primate level. On the contrary, if we assume, in a sound evolutionary spirit, that the loosening of the associated elements begins, with the higher development of the cortex, in the higher non-Primate mammals, we have little difficulty. I contrasted individual and fresh association with instinctive and hereditary association as an increase in plasticity. Here we have an enhanced degree of plasticity, or of mobility of association. No one suggests that the dog had a fully abstract perception of end and means, but we have a process leading on to it. Mr. Hobhouse's position is not clear. Since he admits in the dog only practical, concrete judgments, without perception of relations, one does not see how he would interpret the act. Even when consciousness is introduced, it must have a basis of association.

Both Hobhouse and Lloyd Morgan admit the associative (conscious) interpretation of a not dissimilar observation. A little dog coveted the bone of a bigger one, but dare not touch it even when the other left the room. At last the big dog was heard to bark outside, and the little dog at once took the bone. There is no ground to assume that it drew an abstract inference. Again, however, we may say that the association is gaining in freedom, or is on the way to become abstract.

Romanes contributes stories of dogs which recognised portraits—a matter of sight and memory—and dogs which drew strangers to the help of a master in difficulty. The latter point, which has often been observed, seems to me another instance of the higher type of association. A somewhat similar case in regard to a cat fell under my own observation. In my home a cat was kept which was not suffered to go upstairs, especially at night. One night it came upstairs and made, to my hearing, a persistent and exceptional noise, returning repeatedly after it had been driven down. The next morning we found that the house had been burgled during the night. Here again we have a loosening and re-association of the elements in the cat's mind which goes beyond Dr. Thorndike's formula for the cat. If we could literally accept Romanes's story of a cat which, being used to watch for birds when the crumbs were thrown out, contracted a habit of scattering crumbs itself, we should have another strong instance. But that story will need some corroboration.

One sees at a glance in Romanes's book that the more striking anecdotes are related of animals which associate with men—the dog, cat, horse, and elephant. No doubt, this is at once attributable to the far greater opportunity of observing them, but allowance must also be made for the effect of companionship with higher animals. Compare the dog of Constantinople with the dog of an affectionate master. In the case of the dog, horse, and elephant we must also allow for the effect of social life in the ancestral or wild state. When we glance over the rest of the mammal world we find little claim of more than the simpler associations which an animal may make in novel circumstances, and the great mass of habitual practices.*

The beaver is proverbial for its sagacity, but its remarkable actions are all instinctive and common to the species. The rat has a large repute for reason. Generally, the statements refer to its versa-

* I have omitted elephant stories because the better authenticated all refer to habitual practices, such as testing timber structures or blowing objects within their reach. One correspondent informed Romanes that he had seen an elephant cover itself with grass in the hot weather. It appeared later, however, that this was a common practice.

tility in avoiding traps, obtaining oil from bottles with its tail (a point which Romanes established experimentally), and conveying eggs. Setting aside the less authoritative of these stories, we have a residuum of mental activity which may well be compared with that of the dog. How far the extraction of oil from bottles by the tail may have had an accidental beginning we cannot say, but the extent of the practice is significant. The peculiar conditions of their life, as the special quarry of the most intelligent of animals (man), has exposed them to a special selective process in regard to intelligence, and they seem able to form associations as free and complex as any of the mammals below the ape-level. I have seen a photograph of a rat-trap stopped with teased rope. The photographer declared that the rope was teased, and the entrance stopped, by rats during the night. A number of young rats had been caught, and he presumed that the older rats stopped the trap. At all events the quickness of rats and mice to avoid traps in which their fellows have been caught is well known, and suffices for our purpose. It is not a case of selection of the more wary, as in a large shoal of fish.

The analysis of these cases is by no means easy. We may confine ourselves to an examination of them in the light of the theory that the lower mammal is distinguished from the Primate, or from man, in the nature, as well as the degree, of its powers. The common form of the theory is that the lower animal cannot "reason." More recent students have given a more precise expression to this difference. Mr. Hobhouse puts it that below the Primate level we do not find "articulate" ideas, and his explanation of an articulate idea brings him into line with most other writers. The non-human animal is said to be devoid of abstract, conceptual thought, which is claimed for man alone.

The distinction between an abstract and a concrete idea goes back to Aristotle, and in him it has a sharp significance. The two differ in kind, and have no intermediate stages. They are formed by two totally different "faculties." Now, it seems, on the face of it, doubtful whether such a distinction should find a place in the evolutionary science of our time, and an examination of the facts confirms this feeling. In the first place, too much stress has been laid, in the comparison, on the operation of a cultivated human mind, and too little attention paid to less advanced human beings. It may be said that all human beings have abstract ideas, since they use common nouns and names of qualities and relations. It is, however, well known that language, normally, becomes more and more concrete as we approach the lower level; and we shall see later that there are (or were) men whose language never contained a name for an abstract quality, and whose "common" names by no means indicated the kind of abstract idea that we have.

In other words, abstractness and concreteness are a matter of degree. It does not appear that the extinct Tasmanian had, at the back of his name for tree, any more than a number of images of concrete trees more or less fused, like the images in a composite photograph. Imperfect as that metaphor is, it is by no means impossible to conceive the process. The persistent recording of like impressions may be regarded as leaving a stronger impress of the common and generic features of the images, and fainter and less durable impressions of the features in which they differ. Such a process would be of considerable use to the animal. What, after all, is the nerve-process at the base of an abstract idea in ourselves? Not only must it be somewhat of this nature, but the claim that we deliberately select the common marks or notes of resembling objects seems to be quite opposed to experience. Abstraction is a matter of degree, and Romanes may be perfectly right in attributing generalised ideas to animals. Lloyd Morgan ("Animal Behaviour," p. 167) admits "generalised images."

It is the same with the perception of relations. It is a question of degree. To say that Mr. Hobhouse's animals, after some training as subjects of experiment, were in no sense "aware of what they are doing," is somewhat bold. We must not ask whether they have any perception of relations akin to the sharp abstract idea of such relations in the mind of a scientific student, but whether they have any consciousness of the connection of their act and its result akin to that of a very primitive savage. Or, rather, since even the lowest savage has an immeasurably superior brain, whether they do not show the blurred beginning of the process as we find it in him. It is our own modern European ideas that are always misleading us in this connection. It is sounder to take for comparison the abstract ideas, not merely of a rustic, but of the lowest known savage.

In the characteristic element of the cases of higher mental activity which I have reproduced we seem to have the beginning of this further advance. When the chick avoids a nauseous grub after tasting, just as when the spider rejects a kind of fly after tasting one of that kind dipped in petroleum, we have a simple process of association. When the dog learns not to snap the piece of bread on its nose until a certain number is pronounced—I have known a young bull-dog to learn the trick, in three languages, within a day—we have a slightly more complex association. But when a dog snaps a piece of bread which it usually disdains, because it wants a door opened, or when it drags or calls a stranger to its needy master, or when a cat awakens a household because there is a burglar in the house, we have a different type of association. We have cases of what Dr. Thorndike calls the loosening of the elements associated, the freeing of ideas; which he rightly regards as the next direction of progress. It is a happy phrase, no doubt, and happy phrases have done incalculable mischief in psychology; but it seems to indicate a fact.

Whether we shall call it "reason" or not is more than a mere matter of words. I see smoke rising, and infer there is fire. In all probability the mental act is a mere association of concrete impressions, as a rule. Probably a very high proportion of our inferences are of a similar character, and it would not be difficult to draw up a series of acts of reasoning passing gradually from this to the most abstract deductions, or deductions from abstract principles. If we insist on confining the term "reason" to the higher part of the series, we cannot ignore that the description is arbitrary. In the living order there is continuity. It is difficult to see that any other formula will cover the facts.

On the other hand, we thus get an intelligible view of mind-development. The first stage is a direct response to irritation. The second is the development of an area to receive the irritation more intensely, and a line or path to conduct it to the responding muscle. In a third stage the lines or paths intersect in a central brain, the impressions received are associated, and more complex stimuli issue to the muscles. Intermediate regions arise between the receptive centres in the brain, in which these associations occur. In the instinctive act the stimulus goes straight to its destination, because a straight path for it is inherited. As these association-areas grow, the stimulus is arrested by recorded stimuli, and the instinctive action is inhibited or modified. The animal begins to learn by experience. As the sensory areas grow finer and more discriminative, the instinctive response must slacken. The animal acts more and more discriminately in harmony with each situation. As the areas of association enlarge and develop, more and more remote associations are liable to occur. The animal begins to reason. The incoming stimulus has a larger and freer group of recorded impressions to enter into association with.

Mental states are the consciousness of these increasingly elaborate nerve-processes. Reason, in particular, is the consciousness of the more remote associations of incoming and recorded stimuli. It begins in the higher mammals, develops in the lower Primates, and is carried to a high pitch in the superior Primate.

The aim with which this work opened was, not to offer any detailed explanations of mind at various stages, but to consider whether its unfolding implies the appearance of a new reality, other than ether and its products, in the story of life. Now that we have reached an important stage it is necessary to deal with that point. The evolution of the nervous system is admitted; nor, when we reflect that the world of conscious states assuredly has a corresponding world of nervous states, answering to it in every phase of subtlety and complexity, can the broad lines I have indicated be called into doubt. We may almost conceive the evolution of a race of automata, adjusting their behaviour by the nicest of associations, memories, and inferences.

In fact, however, we are not automata, but are conscious of our nerve-activities. Where does the consciousness come from, and does it not imply the accession of a new species of reality? I seem to have introduced it into the story without a single word on its mysterious appearance.

Frankly, I find no speculation on the origin and nature of consciousness that is worth reproducing, and I assuredly have none to offer. The suggestion of Spencer and Romanes, that it arises from "ganglionic friction"—from the retarding of complex stimuli as they pass through the association-areas—is the least unsatisfactory that has been made, but it is little more than a phrase. It seems to me quite hopeless to speculate on the origin of consciousness as long as its organ is so wrapped in obscurity. And precisely for the same reason I decline to see in it the emergence or accession of a new reality, other than ether, or ether-compacted nerve. Until we know the cortex sufficiently well to say that its structure throws no light on the nature of consciousness, the question must be left open. At present our knowledge of the cortex, the most transcendently important thing that science approaches, is appallingly meagre. What we have yet to discover is so overwhelmingly greater than what we know that it is the most reprehensible dogmatism to say that consciousness may not have arisen in, and be a function of it. Every portion of the cortex has, of course, been submitted to the finest microscopical examination. I am not ignorant of the work of Ramon y Cajal, Flechsig, Waldeyer, &c. But it is none the less true that on the functional side the human brain is still a *terra incognita*. If the recent claims of Professor Loeb are substantiated, the obscurity only becomes deeper.

Any further discussion of the point would take us into metaphysical considerations. I will only observe that consciousness is emptied of all significance apart from nerve-processes. The differences between states of consciousness are wholly due to differences in nerve-processes. The "faculties" or qualities of mind are diverse functions of nerve, of which we are conscious. Does anyone seriously doubt to-day that the difference between an emotion, a conation, a perception, and an inference is determined by the specific character of the nerve-process involved? One might as well doubt that there *is* a specific and distinct nerve-process in each case. Even if, therefore, we have to leave the problem of consciousness open, we have made considerable progress in the interpretation of mind.

From the stage we have reached we now advance to the last ascent. The overwhelmingly greater part of the history of life—twenty-two million years out of twenty-five million, or sixty millions out of sixty-five, as the estimates go—is a period of slow preparation for the evolution of mind. Until the beginning of the Tertiary period it is predominantly, if not entirely, a story of the natural selection of adaptive neuro-muscular mechanisms. Somewhere in the higher part of that series a faint glimmer of consciousness appears, but we have not found a single pre-Tertiary animal whose activities cannot be explained without an assumption of consciousness. Now we approach a period of more rapid development. But we shall see that the constant occurrence of vast changes in the environment, involving, as they do, great changes in the play of stimuli on the animal's nervous system and fresh and freer adjustments, will continue to the end to direct the evolution of mind. If we may borrow the phrase which Professor Armstrong applies to the origin of life, it is largely a matter of "lucky accidents."

CHAPTER X

THE DAWN OF HUMANITY

ONE of the most mischievous and perverse prepossessions in the way of a rational conception of the origin of the human faculties is the very common idea that they break with some abruptness into the chronicle of the earth. People who remain unmoved when you tell them that the story of terrestrial life may have a length of anything between twenty and a hundred million years, or more, seem nevertheless to imagine that the greatest advance in the whole series took place with remarkable swiftness. For this, no doubt, Dr. Russel Wallace is in some degree responsible by having popularised the idea that the higher qualities of the human mind were not evolved, but suddenly engrafted on the powers of the ape.

This idea of a speedy transition is as untrue to the facts as it is misleading, and must be at once refuted. Whatever aid the Mendelist hypothesis may seem to afford in other stages of the story, its abrupt variations are superfluous here. The fact is that the evolution of the human faculties was singularly slow. It is something like 10,000 years since human beings capable of framing an elementary civilisation appeared on the earth. In those ten thousand years the mind has ascended the scale from the level of an Eskimo to the level of a Shakespeare or an Edison. Is the distance in level between an anthropoid ape and an Eskimo greater than this? Yet it took at least a million, and more probably two million years, to cover that distance. The anthropoid-ape level was reached in the Miocene. Man was still a lowly and most primitive savage at the end of the Pleistocene.

If there is anything singular, then, about the evolution of mind at this stage, it is the slowness of pace, not the rapidity. Theoretically, intelligence is so great an advantage that we should expect selection to develop it with exceptional assiduity. Instead of this, it must have remained stationary during vast stretches of time between the Miocene and the Recent periods, or have advanced at an exceptionally slow rate. The truth is, as this and the following chapters will show, that intelligence is an advantage only in relation to environment. The principle of progress is external to the progressing organism, whether it be an individual or a race, if the means of progress are internal. Once more we shall find extrinsic, and what one may almost call accidental, circumstances playing a momentous role in the development of mind.

Let us go back to the Eocene period, at the beginning of the Tertiary. The generalised mammals, which have evolved from the little and obscure insect-eaters of the Mesozoic, are rapidly being shaped into the distinctive types. The theatre of life is changing from age to age. The huge bulk of the Pyrenees and the Alps is still rising, until the Oligocene. The climate is becoming colder, or retaining its low temperature, in elevated regions, but is generally becoming warmer; possibly in consequence of the volumes of carbon dioxide that are belched from the numerous volcanoes which the strain of the crust sets into play. It is a world of changing environment and changing vegetation.

Probably enough, many of the Mesozoic mammals (like the South American opossum to-day) had taken to the trees, and the advance from an arboreal marsupial to a lemur is intelligible. The lemurs appear early in the Eocene, and during that and the following period spread over Europe and Africa. It would be interesting, since so much depends on environment, to determine the region in which they were evolved, but the material is inadequate, and and the point disputed. The survivors of the great Eocene lemur group are found chiefly in Madagascar, with a few in north-east Africa and southern Asia. They are almost all arboreal, and live on fruit and insects.

The evidence suggests, then, that a branch of the early mammals became the primitive tree-climbing lemurs in the changing and stimulating conditions of the late Cretaceous or early Eocene. So transitional are the early forms that Owen described as a fossil ape what turned out to be a Hyracotherium, and Cuvier classed the fossil lemurs as Pachyderms.

Their prehensile fingers and frugivorous, or omnivorous, teeth indicate their climbing habits. The habit, it will transpire, is of some importance. Whether or no these early lemurs descended from an arboreal ancestor, we are easily able to understand the practice. Not only was it a great source of safety against the formidable mammals which now appeared, but it enabled them to reach a fresh and most nutritious kind of food. Fruit-bearing trees were now spreading over the earth for the first time. That single extrinsic circumstance is enough to explain a mode of life which will have an interesting sequel.

The skulls of some of the fossil lemurs (*Anaptomorphus*, &c.) give evidence of the possession of a larger brain than that of contemporary mammals, in proportion to the body, but, if we may judge from the behaviour of the actual lemurs, we cannot credit them with much intelligence. That the brain is a little more developed in them than in their neighbours is not unintelligible. As will appear presently, the conversion of the front extremity into a hand would of itself react favourably on the brain. More important, however, is the fact that, apart from their arboreal habit, they were particularly defenceless in an increasingly formidable world. They had no speed on the ground, and their small size, and modest claws and teeth, unfitted them for combat with the growing carnivores. They used and developed the brain, as the horse used and developed its foot, or the bat its wings.

Nor should we forget, as is so often done, that the improvement in the organs of sense is itself bound to further the mental life. While so large a proportion of the mammals relied on smell, the lemur relied more on sight, hearing, and touch. The touch-area in the cortex has a close connection with the association-area, and the sharpening of the visual and auditory impressions must have been a great advantage. The semi-erect attitude, also was indirectly helpful. It involved a greater activity of the muscles of the face, as well as of the hand, and the motor centres of these are in a favourable position to react on the more important areas. The lemur was, therefore, a promising organism from the progressive point of view, and within a relatively short time it is succeeded by, and largely replaced by, the ape.

The genetic relations of the Primates, which now appear on the scene, are disputed. Some (Klaatsch, &c.) think that the ape, anthropoid ape, and prospective human stocks, branched off separately from the Eocene lemur. Most writers regard the human branch rather as diverging from the anthropoid ape in the Miocene. The point does not much concern us, but the more profitable tendency now is to put back the points of divergence of different families as far as possible. It is enough to note that the ordinary and anthropoid apes are found in Miocene deposits, even in Europe.

Instead of lingering over the particular origin of the apes, and their differentiation into Old World and New World monkeys, we may at once inquire what grade of conscious activity can be detected in the living ape. Though we must allow for later development, the skulls of the Miocene apes show an appreciable brain-growth, and we may approximately determine the unfolding of mind in the quickening period of the early Tertiary by fixing the degree of conscious power in the ape of to-day.

After the lengthy analysis given in the preceding chapter, we need not linger very much over this point. We are prepared to find quicker and more extended associations of ideas in the ape, especially the anthropoid ape, and the little material available, of an authentic kind, bears out the expectation. Although Dr. Thorndike has not conducted his experiments on apes, his surmise that the Primates will show a beginning of the higher development is accurate. We found this beginning, indeed, in other higher mammals; in the anthropoid ape we shall find a great extension of the process, or a much greater freedom and range of association, which leads us on sensibly towards the distinctive character of primitive man.

Mr. Hobhouse conducted a series of experiments with a Rhesus and a chimpanzee. As a result, he was compelled to grant the ape, especially the higher ape, the possession of those "articulate" ideas which he denied to the cat and the dog. He found that they had "an appreciation of the relation between them," and some power of "spontaneous application" of means to end. While a dog, for instance, practically appreciated that a bolt had to be pushed back, the ape appreciated that it had to be pushed back far enough to clear a certain staple.

A very clear and instructive series of experiments was made to ascertain how far an animal could use a curved stick to bring objects within its reach. In sum, the dog and the elephant could learn to draw things to them when the stick was put in position, but not to apply the stick themselves; the ape not only learned—the monkey slowly, and the chimpanzee quickly—to place the stick in a position to draw in the food, but themselves adapted other objects (loops of rope, &c.) to the same purpose. More than one case had been previously reported of apes using one object to reach another in this way. The contrast with the other mammals was instructive. The difference is not merely that the ape has a hand, compared with which even the elephant's trunk is clumsy. There is a deeper significance in the contrast. As Mr. Hobhouse says, the apes have a finer sense of touch, and with this "the degree of their appreciation of objects, their behaviour and relations, seems to be closely correlated" (p. 242). The full importance of this will be better realised when we come to consider the effect on the mind of a finer development of touch in the ancestor of man.

Another interesting experiment, which brought out the mental distance between the lower and higher ape, was to put a banana in an iron tube, and provide a stick for dislodging it. The Rhesus entirely failed at this test, but the chimpanzee succeeded admirably. Another test was to discover if the ape would use a box to stand on in order to reach food placed out of its reach. After some hesitation, it did so. We might compare with this the action of Cuvier's orang in using a chair to stand on in order to open a door; or the action of Miss Romanes's monkey in moving the marble slab, to which it was chained, in order to reach an object beyond the length of its chain. I do not reproduce the other instances given by Romanes, as they have not great significance. That a monkey should avoid wasps after a sting is no more remarkable than that an octopus should avoid an anemone.

The performances of trained apes are only interesting in that they indicate a lively faculty of imitation. On psychological analysis, imitation is seen to involve so complex a mental process that Thorndike and others have refused it to all animals below the Primate level. The refusal seems to be unjustified. Observation of young animals seems to establish it, and the cat I had which rattled the cover of the key-hole—an operation which required some upright stretch—clearly imitated (as it thought) our way of opening the door. In the ape the faculty is, as is well known, highly developed. Mr. Hobhouse found that the monkey failed entirely—even after an accidental unhooking—to see that it could not open a box because a string was tied to the bolt, and held by a hook at the back of the box. But the moment it saw him attach the hook, it mastered the trick. The faculty is not only in itself an indication of a higher power of association, but it is a new and important instrument of advance. As Mr. Thorndike says, it is "one form of the increase of mental equipment by tradition."

We find, therefore, that the ape shows an appreciable advance in the direction of the human faculty. The association-areas are enlarging, and the incoming stimulus has a wider choice or range of combinations. The power of reasoning is growing, and there is more approach—as in the ape using many means to bring in the distant object—to an abstract process. But the whole question will be better understood if we proceed to consider the rise of man from the ape-level.

It is believed by some writers that the living anthropoid apes have somewhat degenerated from the mental standard of the anthropoid apes of the Miocene period. The evidence for such a view it not very substantial, but degeneration is not unknown either in other animal groups or in the human species. If the theory be correct, it enhances the contrast in fortune of the anthropoid-ape stock of the Miocene period which was destined to become the unchallengeable rulers of the earth. We have, of course, no ground to say that any of the anthropoid forms we discover in Miocene deposits (*Pliopithecus*, *Dryopithecus*, *Paidopithex*) is in the line of man's ancestry. An arboreal animal rarely leaves its body, after death, in such a situation as to be entombed and preserved in the mud, and so the remains of the long chain of human ancestors in the Tertiary are very scantily, if at all, known. The fact does not surprise us when we reflect on the extreme scantiness of ape-remains, and on the vast numbers of lemurs and apes that spread over the earth during that lengthy period.

But no morphologist will question that the Tertiary precursors of man passed through a simian phase. The great group of the ordinary Old and New World apes diverged somewhat early from the ascending stem; the anthropoid apes long remain in close association with the ancestors of man. One of the most delicate and recent tests of genetic relationship has fully confirmed this view. It is found that the serum of one animal's blood has a destructive action on the cells of another animal's blood, in proportion to the distance in affinity between the two species. An application of this test to the blood of man and the four anthropoid apes proved that the affinity between them was just as close as had been assumed. The theory was, in fact, already beyond question. In the degeneration of the vestigial organs—organs which, like the appendix or the external shell of the ear, have had their day, and are ceasing to be—the larger apes come very close to man. In the successive degeneration of the teeth the line runs very evenly from the lemurs, through the higher apes, to the lowest human types. In brain-capacity the orang and the chimpanzee come nearest to early prehistoric man; and their semi-erect attitude, which may become quite erect in the gibbon, is an even more significant connection.

It is, therefore, agreed that, however late or early the point of divergence may be, the Miocene ancestor of man was, or resembled, an anthropoid ape. Most writers now look to the gibbon as our nearest relative. We have now to see what light recent research has thrown on the transition from that level to the human stage.

And the first point to determine is, what *is* the human stage? The problem is needlessly and mischievously complicated sometimes by taking an advanced human development as the standard of comparison. We must take the lowest normal human level, and contrast it with the highest known animal level, in any serious discussion of the question. There is a spurious uniformity in the mental manifestations of the members of a civilised community. Vast numbers of even Europeans would sink to a very low level if it were not for the sustaining influence of society, and especially of language. Speech is a buoy, provided by the community, to maintain at a certain level members of the race who would normally sink far below it. By that medium they are enabled to borrow and express ideas of objects and relations which are entirely beyond their native capacity. It is as difficult to penetrate to the normal working of their "minds" as it is to grasp the religious views of a lowly tribe of savages. What they themselves regard with pride as the operation of their intelligence is often only a kaleidoscopic play of phrases borrowed from their journals or from speeches or conversations. Behind their crude formulation one discerns a very primitive, narrow, and concrete intelligence. If we could imagine the disappearance of speech, "the human mind" would quickly cease to be the impressive unity it is.

Until recent years it was usual to say, with Cicero, that "reason and speech" were the distinctive characters of man. As no one now doubts that speech is, like written language, an evolved product of reason, we fall back at once on this deeper character, and need not linger to descant on the recent efforts to discover speech in the dog and the ape. It is now further recognised that man only differs from the lower animal in degree of reason, and fresh efforts have been made to detect a radical distinction. Religion, morality, and polity will not suffice, as they in turn are evolved manifestations of intelligence; the various emotions of man are all found in some degree in the lower world; and "free-will" is so generally challenged by psychologists, even in the highest human types, to say nothing of the Veddah or the Aeta, that it is out of the question.

Several recent authorities, who are nevertheless in entire accord with the evolutionary view, find, as we saw, a radical distinction in the fact that man has abstract thought, and the highest of the non-human mammals only concrete thought. It could not be urged that such a view is discordant with the theory of evolution, if we allow that a transition is possible from one to the other, The lowest human beings have a cranial capacity exactly double that of the highest apes, and although this is a crude expression of superiority, since the cortex is only the film of the brain, there is clearly a great advance of cortical development in the human being. But, while this view may be quite consonant with a theory of evolution, one may very well question if it is a correct expression of fact.

On what test are we going to distinguish between a concrete and an abstract idea? We know that we ourselves have abstract ideas of things, and their qualities and relations, and we know that the higher mammals, at least, have generalised concrete ideas of objects. One part of the advance of nervous systems is that, in registering the impresses of objects, they may retain the features common to a class of things, and neglect the individual and varying characters. The analogy of the composite photograph, in which the general features of a family or other resembling group are more or less clearly presented, has been often pressed. It is, perhaps, somewhat misleading, as there is little analogy between the processes. What we may plausibly conceive is that, as impress after impress of a resembling group of objects falls on the same sensitive and recording area, the common features, renewed in each case, make a deeper and separate record than the varying individual features. Our abstract ideas, it must be recalled, have some nervous process associated with them, which differs from the nervous process associated with the perception and memory of an individual.

Now it is impossible to assign a point at which this process ceases to be "concrete," and becomes "abstract." It is a question of degree of efficiency of the nervous system: probably a question of the deeper expansion of the association-areas between the direct sensory areas in the cortex. That the word "rat" merely calls up in the brain of the dog a crowd of separate impressions of rats is an entirely gratuitous supposition. The dog has, in a lower degree, the nervous apparatus which in ourselves performs the physiological side of "abstract" idea. The ape has it in a more advanced degree. If these animals are admitted—as they generally are—to have "compound sensory images," they have something quite different from a cluster of cohering individual images. They have the beginning of "abstract" ideas, and it is impossible to say how far in them the concreteness has merged in abstractness. The child does not get its general idea by actively selecting the common qualities of a group, but by a passive process of repeated and superimposed impresses. It is notorious that it has to be educated out of its too easy tendency to generalise, rather than that this advances with growth of intelligence.

When we pass to the other term of the comparison, primitive man, we find instructive indications that the advance is one of degree of efficiency. Some of the lowest races are so imperfectly known to us that the inquiry is unfortunately hampered. Sir Harry Johnston, for instance, tells us that certain natives of Central Africa (Ba Nande, &c.) have no language of their own, but have borrowed the tongue of neighbouring tribes. As, at the same time, these peoples are of a very low, simian type, and have not yet reached the level of tribal organisation, it would be interesting to know more of their mental powers. The Yahgans of Tierra del Fuego have a rich language, in curious contrast to the poverty of their peaceful savagery, and one may well suspect that it is borrowed. The Veddahs of Ceylon are said by the most recent investigators to be not quite so low in mental endowment as was supposed. The Aetas and other very primitive peoples are little known.

As far as present evidence goes the extinct Tasmanians were the lowest of known races. If the native Australians represent an early wave of human distribution, long isolated and preserved in its simplicity, the Tasmanians represent a still earlier wave. From the character of their implements these lowly humans, who seem to have been driven south by the invading tribe of the early New Stone Age, are often described as Eolithic men. They have no tribal organisation and no houses. Though they had fire-sticks, they were never known to use them. Fire had to be regularly maintained by them, or borrowed from a more advanced people. The last of the tribe disappeared thirty years ago, before exact and searching inquiry was made into their qualities, but a few indications which survive in regard to their language are of great interest.

Their speech was so rudimentary, and so materially aided by gesture, that intercourse between them was rare and difficult after nightfall. There was no settled order of words, and there were no abstract expressions in their language. A hard object was "like a stone"; a round object "like the moon," and so forth. It is even said that they had no common nouns or general terms, in the sense of names quite detached from concrete and particular objects. The authorities, at all events, are emphatic that there was no word or phrase in the language to express an abstract idea. Even when we pass to the neighbouring Australians, who are of a much higher stock, we find (as in many tribes) an inability to count beyond three or four.

It is difficult to see anything more than a difference of degree between the ideas of these primitive humans and those of the highest mammals. The generalised records of individual impresses of objects are becoming more definitely abstract, but the process of abstraction is a graduated process, beginning in the sensuous compound images of the higher mammal, and not at all far advanced in the lowest humans. We cannot even discover with any confidence that the power of generalising had advanced in the Tasmanian as much as the enlarged brain would lead us to suppose, and, on the other hand, we find it still advancing and imperfect in other primitive tribes. It seems, therefore, impossible to admit that we may cut off man from the rest of the animal world by saying that he has abstract ideas, and the other animals have only concrete ideas. The animal's general ideas are abstract in so far as they are general: the Tasmanian's ideas were of the same order, somewhat more advanced.

There is now no other ground on which man may be sharply divided from the animal world. If intelligence is a generalised term for the capacities of perception, judgment, and reason, it is at least found in the higher mammals. Perception is the consciousness of a presentation; judgment is the association of two simultaneous perceptions (or the mental separation of quality and object); inference is the more distended association of a past with a present association. We cannot at this level take into account the syllogisms of an advanced European. The inference of the savage is that a watch is alive because it moves without being moved. It is a simple association of ideas born of his experience. The inference of a wasp, a rat, or an ape is of the same order. The tamed carp does not "reason" that there are innocent creatures and mischievous creatures, and that its master must, after due experience, be put in the former class. In regard to emotions and will there is an even plainer continuity between the highest non-human mammals and the lowest human.

The problem we have to solve is, then: To what agencies can we attribute the appreciable rise in mental faculty from the anthropoid-ape level to the human? Before we attempt to do so, let us conceive the problem as strictly as possible.

The Tasmanian is not the lowest level of known humanity. We speak of him as corresponding to Eolithic, or early Paleolithic, man, but in point of fact he does not correspond to the earliest known men. The remains found long ago at Neanderthal, and Spy, and La Naulette have recently been reinforced by what are claimed to be even more primitive remains, found at Heidelberg, La Vézère, and Chapelle-aux-Saints. Setting aside all disreputable traces of the earliest Paleolithic race, these remains furnish a consistent type; and it is a type lower, in brain development, than any existing race of savages. Its cranial capacity is about 1200 cubic centimetres. This capacity is found to-day only in races of such small stature that they are classed as pygmies. Paleolithic man was more than five feet high, and had a very robust and powerful physique, so that this low cranial capacity implies a much lower intelligence.

But a still lower type is represented by the remains which were found in Java by Dr. Dubois in 1892. Though the animal to which these bones belonged must have been nearly five feet six inches in height, the skull shows a cranial capacity of between 900 and 950 cubic centimetres—far less than that of the pygmies—and the cephalic index is extraordinarily low. It is now generally agreed that the remains represent a normal type, a type about midway in cerebral development between the anthropoid ape (capacity 600) and Paleolithic man (capacity 1200). Whether it should be called ape or man is immaterial. It is usual now to speak of it as "the ape-man of Java" (*Pithecanthropus erectus*).

The significance of these discoveries will be best appreciated if we arrange them in an approximate chronological series. Absolute figures on such a subject cannot be given with confidence, but a relative scheme, based on a very moderate estimate of the biological record, may usefully be presented. On the lowest calculation, it is about a million years since the Miocene period, in which the anthropoid apes appeared. On this estimate the Pithecanthropus (in the late Pliocene or early Pleistocene) comes some 700,000 years after the anthropoid ape, and early Paleolithic man about 150,000 years later, or about 150,000 years ago. If we adopt the more generous estimate of Professor Sollas and other authorities, we must double the figures. In any case we have beyond question more than 600,000 years between the Miocene large ape and the Pithecanthropus; at least 100,000 years from this to the earliest Paleolithic man; and at least 100,000 years from Paleolithic man to civilisation.

The evolutionist, therefore, finds a problem rather in the slowness than the rapidity of human development. The real evolution of man is comparatively recent, and is illustrated by a vast collection of relics. From the level of the Heidelberg or Neanderthal man the ascent is gradual. Of later Paleolithic remains we have several examples (Chancelade, Sordes, Krapina, &c.), showing the gradual advance. Indeed, if we had no human remains whatever, we could trace it in the crude stone implements. Later still comes a large batch of more advanced skulls, which are variously described as Paleolithic or Neolithic, and which probably represent the transition. From the beginning of the Neolithic the advance is rapid and sensible. Of the absolute value of these periods we cannot yet speak. But if we assign 250,000 years to the whole Stone Age, we must grant 200,000 to the Paleolithic, and 50,000 to the Neolithic. In other words once more we find that in the earlier period the progress is extraordinarily slow.

We will return to the point later. For the moment we must take it as established that at least half a million, and probably much more than a million years, elapsed between the Miocene anthropoid ape, and the earliest Paleolithic man. The only intervening evidence is the shadowy impression of the Pithecanthropus of Java, which it is now usual to put back well within the second half of the period. Hence, instead of having to explain some miraculous and sudden appearance of human faculties, we have merely to suggest how, in the course of half a million, or a million, years the anthropoid brain rose to a level below that of the lowest existing savage.

It is at once apparent why scientific men so confidently assume the evolution of the human mind. The development from the level of earliest prehistoric man to the level of the cultivated European is greater than the distance between the earliest prehistoric man and the highest ape; yet it was gradual and rapid, and is proved to us by a mass of positive evidence. We may assume the earlier and slower evolution. Nor are we wholly perplexed as to the slowness of the earlier development, as compared with the later. As I have said, and we shall yet see more plainly, the means of progress may be internal to the organism—its variations —but the principle is external. Human tribes may retain their low level for a hundred thousand years, if they be not stimulated by clash or contact with a tribe of different culture, or by some other supervening change in their environment. This stimulus was weaker in the early days when Paleolithic man was not yet differentiated into higher and lower races; it was almost entirely wanting in the still earlier phase. We must look for some change in the environment to elucidate the first advance in intelligence.

A good deal of fairly concordant speculation has been expended on the point of recent years, and I will do little more than summarise the suggestions that have been made.* The central and persistent

* Compare the Presidential Address of Professor Cunningham to the Anthropological Section of the British Association, 1901 (*Nature*, September 26); C. Morris's "Man and his Ancestor" (1900); Dr. Munro's "Prehistoric Problems" (1897); Dr. M. Alsberg's *Die Abstammung des Menschen* (1902); and Sir E. Ray Lankester's "Nature and Man" (1905). Sir E. Ray Lankester, however, puzzles one by saying that man had as bulky a brain from the start as he has now. On the contrary, comparing bodies well above the pygmy standard, the Pithecanthropus

idea of these speculations is that a change of habits would suffice to give the Miocene or Pliocene anthropoid an increase of cortical surface. It is suggested that it left the trees, and began to live on the ground. For so simple, and indeed inevitable, a supposition little evidence is needed. Lemurs and Primates are so overwhelmingly arboreal, and the skeleton of early man still so plainly indicates a transition from a climbing to a running animal, that we may regard this as the expression of a fairly obvious fact. The important point is to discover how the change would lead to brain development.

Professor Cunningham has very carefully worked out the probable result on the cortex of such a change. He points out that Flechsig's chief "association-centres," which Dr. Johnston and other writers confirm, are on the frontal and parietal convolutions. In the embryonic development of the brain it is especially here that the human brain differs from that of the ape; and the comparison of the adult brain, and of higher and lower human brains, confirms it. The first increase of intelligence, therefore, in the pre-human ancestor means an increase in this region of the cortex. Now, this region is bordered by the motor areas for the muscles of the arms, hands, face, and mouth, and any special development of those areas would presumably react on the contiguous association-areas. We saw that

has less than 1000 cubic centimetres of brain-matter, Neanderthal man 1200, early Neolithic man about 1400, and the average living European about 1600.

the latter are probably differentiated out of the sense-motor areas.

If these anatomical determinations are sound, we have a not unimportant clue to the early advance. Of an enormous family of tree-dwelling animals, the ancestor of man has been the only member to desert his ancestral home for the ground. The change would involve a great development of the sense-motor area of the hands, which is admittedly in the upper part of the frontal and parietal convolutions. From being an almost passive support of the body in the quadruped, the fore limb becomes a more discriminating organ in the climbing ape. When the ape leaves the trees, and throws all the weight of its body on its hind limbs, the hand is used for even finer adaptations. Its sense of touch is developed, and its use for throwing missiles (as baboons and other apes occasionally do) will tend greatly to stimulate its cortical centre.

Thus the natural adoption of an upright posture and the liberation of the front extremities for finer uses would of itself be apt to stimulate the association-area. But there would be a number of contributory modifications. The muscles of the face and mouth would be effected by the change. The erect posture would directly lead to some modification of these, but if we assume, as we seem bound to do, that there was an accompanying change of diet, the modification would be greater. Morris, indeed, lays the chief stress on the change of diet; and Alsberg and Professor Klaatsch differ little.

Whether the change of diet was the cause or the effect of abandoning the trees, it is not necessary to determine. The fact is beyond question. The development of fruit on the Tertiary (or late Mesozoic) trees had, together with the feeling of greater security, led to the habit of climbing. The abandonment of the habit would necessarily mean a gradual, or at least partial, reversion to a flesh-diet, and the new activities employed in hunting would involve fresh uses of the muscles of the mouth and face. The head would now rotate more easily on its vertebral axis, and the eyes would definitely replace the nostrils as the commanding sense. The development of finer sensation in the fingers would also be a very appreciable contribution to the enlargement of the psychic field.

Mr. Morris and other writers have pointed out most of these incidental and most important modifications, but one may doubt if any writer has yet fully appreciated the share which the improvement of the senses themselves had in the making of man's mind. Some of the lower Vertebrates, and many of the Invertebrates probably, have senses which are so different from ours that we cannot conceive them, and some of the higher Mammals have the sense of smell in a far higher degree than we. But vision and hearing are the great sources of the presentations and emotions which ultimately make up our higher knowledge of our environment. One has only to close one's eyes for a moment to realise how far consciousness is in us synonymous with our sharp and coloured visual picture of our environment. If we further endeavour to erase from our consciousness all that has been contributed by our finer organ of hearing, we realise this very vividly. The difference between man and the lower animal is very largely one of fineness of sense; the advance from the one to the other was, to a material extent, an advance in structure of sense-organs. The ear has been gradually advancing since it—apparently—first began to assume the complexion of a crude auditory organ in certain fishes. The eye has been making a parallel advance. The horse is supposed by some to have an advantage of vision over us, since it can see better in faint light. In reality, the difference indicates our superiority. It means that the cones of the retina, which are concerned in colour-vision, have in the human eye gained enormously on the rods in the area of clearest vision (the central *fovea*), and so we only have sharp images in coloured light. The grey light is the lower animal's natural medium. In the higher Mammals, and especially in man, the retina assumes a finer texture, and records all the stimulating colour (or varying reflective surfaces) of the world. This evolution still continues. The eye of the savage does not see the same world—has not the same range of colour—as the eye of civilised man. Colour-perception probably exists low in the scale; in man it reaches its culmination.

If to this important advance in clearness and richness of vision and perception of tones, we add an appreciation of the fact that the change of environment would of itself not lack stimulation, when the animal left the trees, we realise that the theory which attributes the slight initiation of human intelligence to an alteration of habits does not rest merely on localisations of sense-motor areas in the cortex. There was a comprehensive enrichment of the mental life, even if each change was in detail slender and gradual. The point is that the abandonment of the trees would give occasion to natural selection to promote these advances. New and more numerous enemies would have to be avoided, and in fresh ways. The teeth and claws of the ape would be indifferent weapons among the powerful Mammals of the mid-Tertiary period. The more wary would survive, and breed most. It seems more probable, therefore, that there was an appreciable advance made in the Miocene, and that the new animal, adapted to its environment by this advance, then remained stationary—a common feature—until it was stimulated to advance by a fresh change of environment. We find this fresh change of environment, and advance in intelligence, in the Quaternary.

When we turn from theory to facts, we find that the record, slender as it is, quite confirms these considerations. Most anthropologists agree that man was evolved in the Tertiary, but are by no means agreed that we find positive remains or traces of man in the Tertiary. Eoliths, or crude stone implements, are claimed as primitive man's handiwork in various parts of England, and in France, Belgium, Spain, Italy, North Africa, and India. From the nature of the case, the first human touches on stone would be so slight and irregular as to be with difficulty distinguished from accidental chipping. A large number of the first authorities (Sergi, Mortillet, Klaatsch, Schweinfurth, Hoernes, Rutot, Sir E. Ray Lankester, Professor Windle, Dr. Keane, Dr. Blackmore, &c.) now accept one or other group of these Eoliths, but we need not rely on them. If they are really artefact, they harmonise with the theory that a distinct, if limited, advance of intelligence was obtained in the Miocene.

The first indisputable trace of something above the level of the anthropoid ape is found in the late Pliocene, or early Pleistocene. The famous bones of the ape-man (*Pithecanthropus erectus*) of Java have been so often discussed that a few words on them will suffice. The skull-cap, two teeth, and femur, which Dr. Dubois found—a few yards from each other—in 1892 at Trinil in Java, are now recognised to represent a being midway in development between the anthropoid ape and Paleolithic or low savage man. The cranial capacity is estimated at 950 cubic centimetres, as compared with 600 in the highest known ape, and 1200 in any known human skull belonging to a being of equal size (five feet five inches in height, as measured by the femur). The teeth indicate a jaw-formation equally intermediate, and the femur, though more advanced, is very heavy and curved. The only controversy to-day is whether the being should be called ape, or man, or ape-man, a point on which we need not linger. The bones show that some anthropoid ape had, by the end of the Pliocene or the beginning of the Quaternary reached a level that most authorities recognise as just human, and other authorities—happily for the theory of evolution—declare to be just less than human.

Between this and early Paleolithic man, represented by the well-known remains found at Neanderthal, Spy, Krapina, Arcy, and La Naulette, there was until recently an appreciable gap. Recent discoveries, however, have partially filled the interval. In 1906, a nearly complete skeleton was discovered at La Vézère. Professor Klaatsch regards the remains as more primitive than those of Neanderthal and Spy, and Dr. Reinhardt estimates the age of the skeleton at more than 400,000 years.* In 1907 a lower jaw was found at Mauer, near Heidelberg, which Dr. Schoetensack, to whom it was submitted for examination, declares to be even earlier than the preceding. Finally, a skeleton was discovered at Chapelle-aux-Saints in 1908, which the great French authority, M. Boule, regarded as the most primitive human relic yet discovered.

These three discoveries seem to belong to a stage of human development between the Java man and the early Paleolithic (Neanderthal). Later in the Paleolithic age we have the remains found at Chancelade, Sordes, and Laugerie Basse, and a large group (Tilbury, Bury St. Edmunds, Brüx,

* *Naturwissenschaftliche Wochenscrift*, May 20, 1909.

Predmost, Podbaba, Schipka, Taubach, &c.), which are variously assigned to the end of the Old Stone Age and the beginning of the New. I need only observe that this long series of human skulls and jaws, spreading over a vast number—probably hundreds of thousands—of years, shows a slow progressive evolution of human intelligence. The prognathism is gradually modified, the heavy frontal ridges diminish, the facial index and the cranial capacity continuously rise. The relics of human industry which are found through the whole period, from the Eolithic stage to the Magdalenian, indicate the same gradual and very slow advance. Nowhere do we find trace of a brusque appearance of new powers. The hiatus which was formerly conceived between the Old and New Stone Ages is now substantially filled, by discoveries in the Pyrennean district and Austria, and there is a continuous rise throughout prehistoric times. In the whole vast period from the first use of implements until the last phase of the Paleolithic, man learns only to chip his stones with a somewhat finer touch. The more rapid advance at the end of the Paleolithic we will consider presently.

To sum up this necessarily long account of the development of the human faculty, we may say that the evidence indicates a slowness of advance which must be carefully taken into account in any theory. The anthropoid ape-stage is reached in the Miocene. By the beginning of the Paleolithic age—many hundreds of thousands, if not much more than a million years, later—our human predecessors have reached the lowest level of savagery. The Neanderthal man, powerful in frame but very low in intelligence, differs from the brute only in giving a rough edge and point to his *coup-de-poing*. For another hundred thousand years at least he advances little beyond this stage. We shall see that there is evidence that he had no homes, clothing, speech, or social life until the close of the Paleolithic. To compare him with the Australian native, as is sometimes done, is an extravagant flattery.

That a natural process of evolution could achieve this advance in the course of many hundreds of thousands of years (to follow the most moderate estimate) is not an exacting claim. Indeed, the advance is so slow, as compared with the advance made in the Miocene, and the advance made later at the end of the Paleolithic, that it seems better to conceive the period generally as one of stagnancy, with a few stimulating advances. The first of these crises would be when the arboreal ancestor left the trees, as was suggested. A second might occur when the great Ice Age supervened, and the climate of the northern hemisphere fell. We shall, at all events, find that a later spread of the ice-sheet will have momentous consequences; and we will go on to consider the fresh stimuli that are provided as the human race differentiates into peoples at varying stages of culture, and the main principles of the advance of mind in civilisation.

CHAPTER XI

THE ADVANCE OF MIND IN CIVILISATION

In the preceding chapters no attempt has been made to determine the separate evolution of memory, judgment, imagination, or other distinct qualities of the mental faculties. The omission is not entirely due to the inherent difficulties, which are so conspicuous in the attempt of that nature made by Romanes. The chief ground for refraining from so speculative an inquiry was that, in all these different aspects of mental growth, the element of intelligence is found to be fundamental. The simple form of imagination which the early Paleolithic savage displays in trimming his flints—the single rudimentary indication of imagination we can trace in him—is only another aspect of his slight increase of intelligence. Of his emotions we can only judge on the analogy of those of the very lowest existing savages, and it has been often and abundantly shown that these are an orderly development of the emotions of the brute, again modified by superior intelligence. The radical fact is the increase of intelligence.

This advance, as I showed, does not imply any difference in kind between the human power and the antecedent or ancestral power. If we take perception, judgment, and reason as the three standard activities of intelligence—or, more simply, the perception of objects, their qualities, and their relations—we find these now admitted by nearly all authorities in the higher Mammals at least. Judgment and reason express a growing power of abstraction, as contrasted with simple perception of the concrete object. They are nervous processes of association and of fusion, irradiated by consciousness. But we saw that these processes are found in the brute on the one hand, and are only imperfectly developed in the Tasmanian on the other. There is by no means an abrupt transition from concrete to abstract thought. And when we recollect that hundreds of thousands of years of psychic evolution lie between the chimpanzee and the Tasmanian or the Central African, we may well conceive the process to have been entirely gradual.

We take, therefore, the crude intelligence of Paleolithic man as a nebular reality out of which the many-sided mind of modern man will differentiate. It is much to be deplored that comparative psychologists have not made a severe and exhaustive analysis of the mind of the lowest savage. We have suffered one of the very lowest and most interesting peoples to become extinct, without any scientific analysis of its mental power, and the others (Aetas, Andamanese, rock Veddahs, Yahgans, and sundry Central Africans), whom lack of culture or proper language or tribal organisation stamps as very primitive, are either dying or being rapidly altered by contact with higher races. A severe analysis of one of these primitive minds would afford a useful groundwork for psychology, and a careful comparison of such analysis with the mental equipment of a higher ape ought to be the indispensable starting-point of any speculation on the differences between the human and infra-human intelligence.

Unhappily, we have not nearly complete material for this study. All that we have of importance is the fact that the processes of abstraction and inference are most imperfect and transitional in the lowest savage. Even the Australian, who is by no means at the lowest level, cannot count beyond three or four. The Tasmanian had a far lower grade of abstractive thought, and had so little faculty of inference that, with the borrowed materials for making fire in his hands, he never made it. But even the Tasmanian is higher than early Paleolithic man, much higher (in cerebral development) than the Java man, and higher still than the last stages between the Miocene ape, and the late Pliocene or early Pleistocene Java man. We can only say that, at the beginning of the Quaternary, we find a race with the abstractive and conscious associative power of the ape further advanced, as we should expect, and we must trace the principles which direct the growth of this primitive mind into the higher forms with which we are familiar.

The first principle is the recurrence of an agency which has already played a very conspicuous part in the story. The quickening of the mind of the Paleolithic savage is indisputably connected with a fresh fall in the temperature of the earth—at least that part of the earth, the northern hemisphere, in which we trace the next advance. How early man was affected by the great ice-sheet which crept down over Europe, as far as the valleys of the Thames and the Danube, in the early Quaternary, we cannot say. We find no undisputed traces of man below the glacial deposits of Europe. But even more southern latitudes must have felt the change, and man already existed there; if he did not retreat southwards before the advance of the cold. Such a retreat would involve a stimulating clash of populations, and in any case the change of climate and environment would prove stimulating. The semi-tropical zone which seems to have been the great centre of human development—north Africa and western Asia—would become temperate.

We need not linger over this obscure point since, when we do at last find a quickening of the pace of human progress, it coincides with a fresh, though more limited, extension of the ice-sheet. When the Neanderthal race wandered over Europe, as far as what is now the island of Britain, the climate was more genial than it is now. The hippopotamus and rhinoceros were amongst the animal population. There is no evidence of cave-dwelling, or the use of fire or clothing, in the early Paleolithic or Chellean ("river-drift") period. There is no positive evidence that men yet lived in social groups, and some evidence that they did not. The Paleolithic "workshops" belong to a later date. The earlier implements are scattered, and suggest that the anthropoid-ape habit of living in isolated families still persisted. Dr. Munro and others have pointed out that—as I have verified on examination—the tubercle in the early Paleolithic jaws, to which the tongue-muscle is attached, is very faintly developed, and that this points to a lack of articulate speech.

In the next, or Mousterian, period, the temperature of Europe slowly falls, and in the Magdalenian the climate becomes sub-arctic even in southern Europe. The reindeer wanders as far as the Pyrenees. Whether or no there were isolated cave-dwellers in the earlier period, we now have a general practice of living under rock-shelters and in caverns. The contents of the caves of Derbyshire or Devonshire are British specimens of a vast cave-dwelling population of France and the Pyrennean district. And the change, which is obviously related to the fall of temperature, has momentous consequences. Men begin at last to live in large social groups, to make fire, and to wear clothing. The sites are discovered of large settlements, with great heaps of animal bones and the debris of stone-fashioning. Flint scrapers and bone needles give the first indication of the use of animal-skins for clothing. The means of communication would now be enormously cultivated, and articulate language would be bound to evolve rapidly.

Towards the close of the period the artistic instinct was developed in these cave-dwelling communities. A naive limitation of intelligence accompanies the fine skill that is developed in line-drawing, and we have illustrations of all phases, from the crudest outlines of animals, thrown together without the least sense of grouping or perspective, to the "reindeer of Thayngen," and the wonderful frescoes on the walls of the great Pyrennean caverns. I need notice only the human subjects. The bodies are always depicted nude, and there are the same marks to indicate a conspicuous coat of hair as on the bodies of the horse and buffalo. It is also worth noting, since some popular writers, misled by the public reproductions of these drawings, have commented on the artists' sense of decency, that the drawings are usually modified in reproduction, and in reality indicate the entire absence of any such feeling of modesty.

The Old Stone Age ends, therefore, with a comparatively rapid advance, after a very long period of so slow a growth as almost to amount to stagnation. The complete transformation of environment, and the adoption of social life are responsible for this advance; and these changes are due to the alteration of climate. Once more a great physical change in the environment leads to a great development of mind.

In earlier works of anthropology a mysterious gulf was placed between the Old and the New Stone Age. It was surmised that the Paleolithic race was extinguished, and a new race, with higher culture, invaded Europe. It would not be impossible to suppose that plague, cold, or floods had thus driven the old race out of Europe, and that, as development continued in north Africa, a branch of the next race came from there when Europe again became habitable. French and German authorities, indeed, now claim continuity of culture, even in southern Europe, but on the whole it seems likely that there was an invasion from Africa (then connected by land-bridges), and that the culture of the Neolithic Age was developed there. It is enough to note that a race with rudimentary agriculture, pottery, and weaving, and a few tamed animals, now overspreads Europe.

It would prove too confusing here to set forth the various speculations of the authorities as to the movements of population from this point onward. Whether the Eskimo are the relic of the Magdalenian population, and the Iberians a relic of the early Neolithic, whether Europe was then invaded from Africa or from Asia, are points under dispute. The evolution of culture from the end of the Paleolithic to the end of the Neolithic is so gradual, at one point or other, that we need not linger. The discovery of fire may have been due to attempts to make stone-implements out of iron-ore, by chipping it with flint. The invention of pottery may have been due to the coating of the joint with clay, to prevent burning; though we have earlier hollowed vessels of stone. Similar origins are suggested for all the other distinctive elements in Neolithic culture. While the stone monuments and tombs which soon appear indicate that the growing intelligence of man is rising from the ground and taking a broader survey of the world in which he lives. The evolution of religion and morality is too large a subject to be treated here. That they were evolved, the living primitive races amply testify.

In this increasing development of mind a new and most important agency must be recognised. One of the indirect effects of changes of environment, migration, is discernible throughout the whole story of life. A species might evolve through adaptation to a changed environment, or it might migrate and evolve by mingling with other species. The latter agency now becomes the chief evolutionary factor. The human family, spreading from its primitive home, had already differentiated into races. Certain skeletons in the Mentone grottoes show that the negrito was distinctly evolved by the end of the Paleolithic.

This constant clash of different varieties of the same species, with very different levels of culture and a high power of imitation and communication, is the new fact in the development of mind which explains the increase of pace. Where a fragment of the species was cut off from this stimulating collision, it remained at the level of culture which it inherited at the moment of isolation. The earliest wave of human distribution was pressed ever onward by the succeeding higher wave. At the extreme tips of the continents, in sheltered forests, and in detached islands, we find these races to-day, shrinking from the advancing culture of the world. A glance at the map explains the primitive culture of the Veddahs, Andamanese, Aetas, Tasmanians, Bushmen, low central Africans, and Yahgans. The Australians and Melanesians represent a second wave, isolated at the next stage of culture and (in the former case) lacking stimulus to progress for, possibly, a hundred thousand years. When this stimulus has been long removed, the brain ceases to be educable (in the race—individual variations may occur). The skull closes firmly over the brain, to give a compensating strength for the expansibility which is no longer needed. The child of the black learns easily, but at puberty the skull closes and arrests growth. It is the same arrest of brain-expansion as in the anthropoid ape.

On these principles we can understand the steady advance of mind under civilisation. There is no intrinsic principle of progress in a race. Just as we have found throughout the whole story, there must be possibility of progress within—selectable variations—but the stimulus to progress is without. A nation may advance slowly owing to the clash of individual minds within its frontiers. The conservatism of human organisations usually prevents this, however, and the nation is very generally doomed to stagnation, if it have impenetrable frontiers.

In this light we may glance at the civilisations of the east before we trace the stream of European culture. Whether the early Chinese civilisation developed in isolation we may seriously doubt. There were great and obscure movements of the "straight-haired" branch of the human family in prehistoric times. It is enough to note that the earliest Mesopotamian civilisation was founded by a branch of it. In any case, the Chinese Empire has been so effectually isolated from equal or higher races within historic times that its stagnation is an obvious geographical feature. The earlier advances, which were codified and stereotyped by Lao-Tse and Kung-fu-tse 2500 years ago, are too obscure for us to speculate upon. The later conservatism is intelligible enough. Until recent times no sufficient glimpse of a contrasting civilisation was obtained by China. One cannot regard the advent of mediæval missionaries or later traders as an adequate stimulus.

Japan, in turn, is not less intelligible. Arising probably from the fusion of a branch of the civilised Mongols with blood from the southern islands, it has experienced only two great developments in the course of its known history. The first was due (during our Middle Ages) to the full admission and adaptation of Confucian culture from China: the second to European influence in our own time. Whether the latter movement is in the nature of advance is a matter of opinion.

Passing over the various Mongolic and Turkic peoples of Asia, who have remained so stagnant in their isolation that they may be to some extent no longer educable, we follow the drift of the straight-haired race across the ancient land-bridge to America. If the Eskimo are, as is generally supposed, a branch of the race that thus wandered afoot from Siberia to north-east America, they afford an interesting glimpse of the early Mongolic people. Surrounded by their repellent deserts of ice, they have received little or no stimulus from other peoples until recent times. Flinging off these regiments into the Arctic as it passed—if the current theory be true—the main advancing body poured into, and spread over, America, and developed into the Amerinds. Native American culture had no stimulus from the rest of the world until the advent of the Spaniards. From the Eskimo of the north, or the Caribs of the centre, or the Botocudos of the south, we find every grade of culture up to the remarkable civilisations of Mexico and Peru and Yucatan. It is not without significance that the higher advances of the Amerinds take place in central positions, with obvious traces of the conflict of peoples, but they need not detain us. I would only observe that these civilisations were advancing at the time the Spaniards came, to reduce them eventually to barbarism. In Peru the priestly demands for infants' blood had been resisted to the extent that the babies were no longer killed. In Mexico we find a prince building a temple in which a new cult, with flowers substituted for human sacrifices, was to be inaugurated.

From these abortive developments, in which the needful stimulus is either entirely wanting, or feeble or intermittent, we may turn to survey the main stream of human development. Tracked to its ultimate sources, the civilisation of Europe begins with an advancing Neolithic culture in Egypt 10,000 years ago, and on the heights overlooking the valley of Mesopotamia some 8000 years ago. The origin of the earliest Egyptians is obscure. Most writers regard the valley of the Nile as a battle-ground of conflicting tribes between 8000 and 6000 B.C., and believe that the founders of the dynastic civilisation about 6000 B.C. came from the east, or south-east. What indications there are point to a great ferment of tribes, partly Turkic and partly Semitic, in the region of Syria and Arabia, from which tribes successively emerge to found the civilisations of the Egyptians, Babylonians, Assyrians, Hittites, Phœnicians, Persians, and Jews.

It is not my purpose to trace, even in broad lines, the development of these civilisations. In the case of Egypt the evolution has been amply recovered. From the primitive culture of the Stone Age, the Egyptians gradually rise to a higher art, the use of metal, an elaborate system of religion, a lofty code of morals, and a vast policy of imperial and commercial expansion. In the course of time their enlarging sphere touches the fringe of another developing civilisation. The Mongolic Sumerians, of whom we first catch sight on the hills above the Babylonian plain about 6000 B.C., move into the valley, are joined and superseded by the Semites, and the empire of Babylon begins to expand from about 4000 B.C. Here again art and religion develop, morality—witness the fine Code of King Hammurabi (written about 2180 B.C.)—reached a high level, and there was the same imperialist and commercial expansion.

It is probable that a third civilisation was about the same time developed in India by the Caucasic invaders, who descended from the hills on the earlier population, and that in the course of time it had communication with Babylonia. However that may be, fresh civilisations—those of the Hittites and Phœnicians, for instance—sprang up in the fateful Afr-Asiatic region, which, long before 2000 B.C., was crossed and re-crossed by the military and commercial representatives of civilisation. The contrast to the situation of China was extreme, and India was little better situated than China. The fertilising stream set definitely westward. The sea had long retreated from Babylon, while the Mediterranean lay invitingly open to the fleets of Egypt and Phœnicia.

After 1500 B.C., we find the Persians rising to a higher culture in eastern Asia, and a fresh civilisation, the Ægean, rising at the point where Europe touched the Afr-Asiatic centre of development. The earliest Greek civilisations are making an appearance, at Mycænæ, Troy, and Crete, in close touch with the older civilisations. About 1000 B.C. Italy in turn is affected, and the Etruscan culture begins; while the founding of the remote colony of Carthage gives promise of a fresh stimulus to Europe. The older empires, sapped with luxury and parasitism, are decaying, and the younger races are preparing to take over and develop their culture. Persia (about 500 B.C.) makes the first great synthesis of the products of the long evolution, but rapidly decays in turn. The Alexandrian military combination that succeeded it may be almost neglected from the cultural point of view. The old culture was crystallising about two nuclei; Greece in the west, and Judæa in the east. It is probable that Judæa, apart from the momentary and borrowed splendour of Solomon, did not become a civilisation until after 500 B.C. By that time, too, Rome was but a small town spreading from the Palatine over the other six hills.

The further development may be briefly summarised. Greece rapidly develops its inheritance, enriches the whole Mediterranean with its brilliant products, and sinks in turn into decay. Jerusalem and Alexandria have preserved what remains of Assyrian, Persian, and Egyptian culture, tinged with the all-pervading Greek culture, and give birth to Christianity. Rome spreads, from its seven hills, over the world—over Alexandria (the new Athens) and over Judæa—and slowly absorbs their culture into the veins of Europe. The earlier Emperors, appreciating the fatal cupidity of their predecessors, and themselves influenced by the growing Stoic doctrine of brotherhood and humanity, extend the advantages of their civilisation over their vast empire, and bear even the symbols of Asiatic religion as far west as Bath and York. The great streams, into which the early rills on the Syrian hills have broadened, are poured out over the soil of Europe. It is enriched with a culture drawn from Egypt, Babylonia, Persia, Phœnicia, and Greece, to which has been added the riper experience of Rome.

In face of these facts it is futile to seek mysterious reasons for the advance of mind in Europe, and its stagnation in Asia. Europe became the centre of the world by the inherited wealth of eastern Asia, and geography explains why the tide rolled westward instead of eastward. For a time, it is true, Europe failed to develop the immense resources entrusted to it. Barbaric floods broke the Danube-Rhine frontier of the empire, and swept over its civilisation. Barbarians, however, are more wont to take over than to destroy. It was the disdain of culture with which they were inoculated that explains the stagnancy of the Middle Ages; and it was a fresh contact with culture that put an end to the stagnation. Partly from contact with Arabian-Greek culture in Spain, partly from the ejection into Europe of the Greeks by the Turks, Europe was stimulated once more, and science, art, and social life developed afresh. Spain and Russia linger still, to prove how little internal principle of progress there is in a race, and how much depends on geographical situation and lack of spiritual frontiers.

In our day the advance of mind is more rapid than it has ever been in the history of the world. A nervous system is being spread over the planet, and the stimuli that are felt at the centres to-day are felt to-morrow at the ends of the earth. No race is so lowly or so remote but that the increasing stimuli impinge on it. Ineducable races are perishing; nor, indeed, does modern civilisation take care to ascertain their educability, before thrusting them from the planet. The general level of intelligence and feeling is rising. Genius becomes rarer, it is true; and the imaginative power decays rather than advances. But genius depends less on external stimuli than on some obscure and as yet uncontrollable conjunction of germ-determinants, and imagination is at first enfeebled by the great wealth of illustration which popular art supplies. We leave it no room for creative exercise. It must be remembered, however, that in the two activities which chiefly absorb the advancing reasoning power of men—mechanical construction and scientific research—a vast play of imagination is involved.

The pace of progress in our time is not a secure foundation on which to erect a prediction in regard to the future of mind. We need no longer dread the retarding of development by a barbaric overthrow of civilisation. The invention of explosives and arms of precision puts a horde of splendid barbarians at the mercy of a corps of anæmic clerks. China alone is even mentioned in such a connection; but China is equal to Europe on the moral side, and could not overthrow it, if it would, without first absorbing its science and more concrete culture. Nevertheless it is a mistake to assume that the pace of progress will continue to increase, as it has done in the nineteenth century. If, indeed, any such anticipation were well grounded, the prospect would be extraordinary. If we eliminate from history the periods of stagnation and reaction, we find that our civilisation is due to a few advances, each lasting a few centuries. If such periods of reaction are no longer probable, and since astronomers predict a future for humanity of not less than 10,000,000 years, it would follow that we can no more imagine the civilisation of a remote future than the dog can grasp our civilisation to-day.

It is, however, not at all clear that the pace of progress is likely to continue. When that vast scheme of intercommunication, which men are constructing, is finally realised, there will be a conspicuous tendency to homogeneity and equilibrium. The great stimulus of diversity of cultures, which has been so effective throughout history, will gradually disappear. The process is going on, and promises to increase. Whether deliberate education will find a substitute for this natural stimulus—just as artificial selection may supersede natural selection—is not determinable. Modern education gives no promise as yet of attaining such a result. We do not see the future evolution of mind even darkly, as in a glass.

But we do foresee its ultimate fate. The time will come when humanity—a race of geniuses, judged by our modern standard—will wage the most titanic struggle that will ever be recorded in its calendar. Our sun must die, as other suns have done and are doing; and no human art can create a substitute for its streams of energy. Slowly the red rays will grow feebler, and the arctic temperature creep toward the equator. All the magical engineering of that future race will be applied to prolonging the last hour of humanity's life. At last the central belt of the earth will sink to the cold of space, and the marvellous structure of brain will succumb to the natural forces which engendered it, and sink back into the elements from which it was so slowly and so subtly compacted.

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