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MATTER MAN AND MIND

The wise decide not what is good or bad,
Till they have tested merit for themselves.
A foolish man trusts another's judgment.

KALIDASA
(Hindoo Playwright, A.D. 250)

MATTER MAN AND MIND

BY W. F. F. SHEARCROFT

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PREFACE

"*I have seen wonders; for you must know that . . . I have a kind of itch to know everything.*" SANCHO IN "DON QUIXOTE."

I HAVE no apology to offer for the appearance of *Matter Man and Mind.* I wanted to write it. I hope that it will not fill a long felt want, for any fool can write that sort of book, a sentiment that is an opportunity for my reviewers, presented with my compliments. Possibly, I have an explanation for the wide range of subjects included in these essays. The Biologist tells us that we should take the greatest care in the selection of our parents, and the Moralist follows with the accusation that children are proverbially ungrateful. Let me take a middle course and acknowledge my indebtedness to my parents for a constitution like a horse, and a mind possessing insatiable curiosity. Further than that they are absolved from all blame. The aforesaid constitution, as the lawyers have it, has made possible the partial satisfaction of the curiosity, and *Matter Man and Mind* represents some of the midnight oil burnt while exploring interesting fields of scientific inquiry.

The subject matter, that I have selected for presentation here, possesses an inherent fascination that is not added to by the skill of any writer. That it enters deeply into our everyday life is undoubted. In its arrangement I have tried to give a wide view of the structure of life, beginning with the solid crust of the Earth as a foundation. The introduction and evolution of life on the surface has been painted in broad splashes, and the Mind of Man, the crowning product of creation, I have tried to show as a thing of might and majesty.

I feel that at times I have pointed the moral too frequently, yet perhaps I have not sinned in so doing.

The educated public desire to know as much what science means as what it is doing. Wide-flung views of progress are a necessity, and their application to our lives needs pointing in no uncertain way, if humanity is to make the best of the future. There is little opportunity for the research worker, engrossed in his experiments and theories, to provide this basis for the intelligent co-operation of the masses, and without this co-operation his work is of little value.

My wanderings in search of information have been pleasant excursions. My hope is that they will lead others to follow in my footsteps—and further.

It remains for me to thank the many workers, the product of whose minds I have laid under tribute. To my publishers also my thanks are due for their unfailing courtesy, help and constructive criticism. To my wife thanks are inadequate, so I offer sympathy, for she has suffered much by draft chapters, MS. and proofs.

W. F. F. S.

PETERBOROUGH
October 1925

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MATTER MAN AND MIND

CHAPTER I

INTRODUCTION

"*Let us remember please, that the search for the constitution of the world is one of the grandest and noblest problems presented by nature.*"

GALILEO.

PROFESSOR DRY-AS-DUST is often represented as the expositor of science. Certainly the very word "science" conjures up in our minds formulæ, symbols and masses of Latin names, distinguished neither by their clearness nor their obedience to the rules of accidence. Such a preconceived idea places any popular scientific exposition at a two-fold disadvantage. On the one hand, there is the general reader who wonders whether anything that is readable and understandable can really be science, and not merely a sacrifice of accuracy for the use of startling phraseology. On the other hand, there is what Kipling would call "the very specialist, O Beloved," who is given to scorn anything, the reading of which does not produce a pain in the head.

There is much to be said in favour of the latter attitude. The foundation of all scientific work is accuracy. Certainly it is only a relative accuracy, the best that can be done at the time. To attain the maximum accuracy it is essential that the records of work done should be written in such a manner as to make misunderstanding an impossibility. This desirable result is attained in scientific circles by the use of a fearsome vocabulary of scientific terms which have been precisely defined, and by the addition of the uninspiring but very safe symbols of mathematics. Hence scientific papers often read like the nightmare of a mathematician, or the raving of a mad lexicographer, and their perusal needs a special training.

This would not matter if science were a matter for the expert only. We do not mind if the man who tinkers with our motor car speaks a technical language that is unintelligible to us, as long as the thing goes when he leaves us. Science is more than this ; the discoveries of the past century and the developments of the present have given us a structure that few can pass by without noticing it. Year by year we recognise more clearly the scientific basis of life. There are other aspects of life beside the scientific, which may be equally important. Poetry and the various arts are an integral part of the fabric of civilisation, essential in every sense. It would be a warped view to see scientific progress as nothing but a complication of future mechanical advantages. A picture of nothing but engines, wires and buttons to press may be rather exciting, but it would provide a very unsatisfying life. If science had nothing but this to offer, it would still claim a foremost place in our considerations, but there would be little need for any popular exposition. Here we should only need the expert designer and the clever constructor. The general public would only need to give orders for what it required and press the appropriate button when it arrived.

Science, however, has more to offer than mere wires and buttons. We gladly acknowledge the debt for utilitarian advantages that the applications of science have given to mankind. In fact, it is difficult to see how any scientific advance can fail to be associated with further applications to daily life, but there is more in it than this. Science rivals poetry and the arts in its employment of the imagination. It is a philosophy, a way of looking at the Universe, and as such it wields its greatest powers for the benefit of humanity. We may even draw a distinction between scientific knowledge and scientific method. The former is the organised body of facts that have resulted from the application of the latter to the problems of life. The facts are relatively unimportant, vast as their significance is; the spirit of science is its method which makes the dead bones of fact become living organisms pulsing with life and energy.

It is here that popular exposition claims to be a necessity, for those who have been trained in the ways of science, believe that the future will be dominated by the race that is best prepared to see problems in the scientific way and attempt to solve them by scientific methods. We can go a step further even, and claim that the future of humanity depends upon this realisation of the aims of science, and an appreciation of the worker in the research laboratory or the wide fields of Nature. In this book we hope to unfold a story which leads to a conclusion that is a triumph for Man, as the principal form of life on the Earth. Yet however firmly we may believe this, we cannot but realise that his existence *is not a necessity*. In the picturesque language of Sir William Osler, "civilisation is but a filmy fringe on the history of man," and humanity may be likened to the youngster just leaving the shelter of the family for the wider life provided in the University of the world. So much depends upon the direction taken and whether the first enthusiastic efforts are of the nature of a blind rush or tentative exploration. Humanity can at its present stage of progress make mistakes that would be irretrievable. Within certain limits Man is master of his fate. He can chose the direction in which he will go. To-day he has his feet planted firmly on the main road of progress, but along this road there are some very inviting by-lanes, with shady pastures and trickling streams, and they lead nowhere.

The trail is blazed into the past, but no man can see very far ahead. The pioneers of the road are the scientists, the poets and the artists, all of whom have a single aim—the painting of an ideal. The scientist makes the road firm and safe, he scouts ahead for possible dangers and false tracks. The poet and the artist build the picturesque structures by the wayside, that make the journey a dream of delight for those who have ears to hear and eyes to see. Much of the progress of the past has been slow, much of it has been blind struggle in which numerous parties have been wiped out as a result of following blind alleys. The present time is one when humanity is insistently calling for rapid progress, and the map that the scientist is making must be studied by the masses, if the call is to be met successfully.

Science offers not an immediate solution of all problems, but a way of tackling those which are urgent and a vast array of relevant fact for the guidance of this work. It is not given to all men to advance the material facts of science, but each one of us can appreciate the scientific method, use it in our own lives and see that it is properly applied to the larger movements of the whole human family. Thus it becomes the task of the popular expositor, not to write down his subject as for some lower order of intelligence, but to unlock the storehouses of science and bring forth the rich treasure which can be found there. He is, as it were, a correspondent from the front line of Man's attack on the future, giving a reasonable account of what he has seen. His story will obviously lack the detail of the reports written by those actually engaged on the task. He will best serve his purpose by endeavouring to outline broad movements, announce advances, stress danger points and urge the loyal support of those in the trenches. Thus humanity will be able to take its true share of this offensive and co-operate with the Chemist, the Biologist, the Physicist, the Mathematicians and all the other experts. In such co-operation and intelligent appreciation alone can success be found.

Such is the aim of popular science, but it is necessary to define its limits. It may be possible with a fair degree of accuracy to give an account of the broad outline of scientific achievements. It must, however, be realised that such accounts will not turn any individual into an expert. In every branch of life expertness comes only after prolonged effort. Let us take the analogy of an army. Success in the field depends upon two factors—the expert tactics of the leaders and the intelligent co-operation of the rank and file. The finest tactics in the world will fail if the support of the privates is not forthcoming, and this support is only certain, when the command sees that the various operations are reasonably explained to those who have to carry them out. It may not be necessary for every soldier to be an expert in the science of tactical movements, it may not be necessary for him to be versed in all the intricacies of diplomatic negotiations, or the mathematics of gunnery, the chemistry of explosives or the theory of medicine; but unless he has the confidence that only comes from intelligent participation in all these he will fail in the hour of need.

So it is with the battle of life. We must all understand the instructions that we receive from our tactical leaders, the scientists. The better we understand, the closer will be our co-operation and the greater the advances we make, and the fewer the casualties by the way.

CHAPTER II

FLOATING CONTINENTS

"The time has all but come, when the Nature that administers the whole, shall transmute all that thou seest, using the substance for new creations, and the substance of these creations for others, that the Universe may for ever renew its youth." MARCUS AURELIUS.

" As firm as a rock," " as enduring as the solid Earth," are utterances that have passed into the currency of everyday speech. We live, we move, we have our being on a solid crust that was here yesterday and, we fondly hope, will be here to-morrow. Our fathers speak of the bygone days in terms that are familiar to us ; history names the mountains and rivers that we know to-day. If we meet with change that is marked, we can usually attribute it to the hand of Man, as where he has ravaged the forests, blasted the rocks, and dammed up the waters.

Truth, however, appears to lie entirely in the opposite direction. We have but to scratch at the surface of the Earth to realise that it is an ever changing area. Nothing is constant, nothing is fixed. The rugged heights, that tower into the sky and crown the mountain ridge, are but monuments carved from gently rolling folds of land. The clay from which we make our bricks is the product of decay of masses of granite. The tops of the Alps were once the floor of an ocean, the ocean bed land of other days. " Change and decay in all around I see," says the hymn, and, if morbid, at least it is scientifically correct.

This crust of the Earth on which we live has a fascinating record in the annals of science. Much of our conception of its nature must, of course, be related to our theory of how the Earth originally became a unit of the solar system. There have been many theories on this point and in our own time there are a number from which we may choose. The older theory of Laplace which figures so prominently in popular imagination must, in the light of more recent work, be abandoned. Laplace imagined a massive Sun, in a state of gas such as we find in the many nebulae seen at present in the far depths of space. Such a mass was supposed to be in rotation, and thus was set up a condition of instability which resulted in the break up of the nebula into the sun and the planets. Such rotational instability has been shown to be "not a possible explanation of the origin of the solar system." Of other theories which exist that which suggests a formation of the solar system as the result of tidal action in the original mass, seems to offer the most reasonable field of speculation. According to this theory "the sun while in the giant stage is supposed to have been broken up by the tidal action of a passing star several times more massive than itself. . . . The ejected matter, as it emerged from the sun, collected into nuclei. These continued to move outward, but were deflected sideways by the star, and thus proceeded to move round the sun in one direction and nearly in one plane. . . . The condensation of the greater planets was a straightforward process, each passing steadily through the gaseous state to the liquid state, through loss of heat by radiation from the outside. The smaller ones and the satellites had a more complicated history. They would form drops at the outside, and these would fall in towards the centre, forming liquid cores, but at the same time a large fraction of their mass would probably be lost. . . . All the planets must have gone through a liquid stage, passing gradually into the solid state by cooling from the surface." Another theory which has attracted much attention is the Planetismal Theory which supposes that the drops, formed at the surface of the cooling planet, would solidify there, and then fall to the centre forming a solid mass, which never had been through a liquid state. It is not our purpose to enter into these theories, but we may note that they share in common the suggestion that the actual crust is a comparatively light layer of material, while the interior of the Earth is composed of heavier material. The less we say of the nature of this interior the more likely we are to avoid controversy. All our evidence is indirect, and so open to more than one interpretation. The crust itself of which we have definite information is but a thin skin over the globe. Our deepest mines are represented on a two-foot globe by the merest pinprick in the varnish, and the Himalayas could be modelled on the same scale by a single thickness of cigarette paper. It is in this skin that our present interest lies.

As a scientific study Geology is one of the young sciences, and, prior to the eighteenth century, there is little but the vaguest of speculations: so wild, in fact, as to have little bearing on the present. There were some happy guesses in pre-Christian times, but, from the fall of Rome till the Renaissance, men were more occupied with theology than any other "ology." Still in this dim past we may recognise two schools of thought, for which we can offer a reasonable explanation. Early civilisation appears to have centred round the shores of the Mediterranean, which does not prejudge a possible origin somewhere else. In such an area men would be sharply divided as to their environment. There would be those who lived in the valley of the Nile, experiencing a beneficent Nature, contributing to the fertility of their land by the annual flooding of the river. All would be quiet and peaceful. Others would live within the area of volcanic action, and possibly witnessed the inrush of the Atlantic over the ridge that is now the floor of the Straits of Gibraltar. Such happenings would spread ruin around them and convince the inhabitants that change was a matter of sudden violence.

We find the influence of these two opposed conceptions almost down to our own days. We see the great naturalist Buffon (1707–1778) teaching that the Earth and all the planets were a part of the Sun, and at some time a tremendous collision split up the original mass and formed, as it were, a ready-made Earth, all complete with mountains and valleys. Fossil remains were a stumbling-block to this idea. The common belief in England was that they were natural objects, such as the rocks in which they were found, a view that did not meet with approval from a keen observer like Buffon. He supposed that at some remote past time the Earth, mountains and all, was covered with a universal ocean in which the creatures, whose fossils we find, lived and died. Here we have the violent beginning put on a slightly higher level of thought, in which hot masses are made the means of originating the crust of the Earth.

Werner (1749–1817) taught, on the other hand, that the rocks were all deposited from some primal ocean. He even went so far as to state the order in which they were formed. Here we have a quieter method of semi-chemical precipitation. The theory, however, did not offer any explanation of volcanoes, which were dismissed as literally burning mountains.

Much of this was but pure speculation, and we have to come down to the day of Hutton before we get anything founded on true observation. In 1785 Hutton published his famous *Theory of the Earth*, but died some twelve years later before the value of his work was recognised. His school of thought was vigorously carried on by his disciple, Playfair. According to Hutton the crust of the Earth formed, as a solid layer, on the still very hot interior, but its form was not fixed for all time in that process. Years of research had led Hutton to see that other forces had been at work since that original solidification.

These forces were what we recognise now as the agents of denudation, the gradual wearing away of the land by the action of rain, rivers, wind and frost. Such slow-acting forces would carve the mountain masses into valleys and crags, and, in time, plane the whole down to sea level. Hutton went one step further, recognising that the material carried away must be deposited somewhere. He traced this down to the sea and foresaw the growth of new land forms, such as, for example, we can note within historical times in the silting up of river mouths and the formation of deltas. Hutton's views were destined to have a stormy career. However the crust had been formed, it was thought that it was fixed for all time, and any idea of a perpetual change was entirely repugnant to the general trend of thought in those days. Slowly the new ideas gained acceptance, and in 1862 the geologist, Jukes, read a masterly paper on the subject, which "started the vigorous study of the origin of landscape which has been so characteristic a feature in geological activity" ever since.

To-day we have general agreement on the subject; an agreement that is in the nature of a compromise. It is recognised that the gradual processes of denudation are responsible for much of the carving of the mountain ridges into complicated systems of valleys; that the original folding of the crust was due to world-wide movements none too clearly understood, and which even to-day are still taking place; that cataclysmic action, such as volcanoes and the raging waves of the sea, has had its share in the making of the world as we find it.

This agreement rests on a basis of time. Enormous periods are needed for such slow-acting forces as these to produce the mighty changes which the story of the rocks suggest. In Hutton's day there were but some six thousand years available, a figure arrived at by complex reasoning from the story of the Old Testament. Such a period was totally inadequate, and the suggestion that Chapter I. of the Book of Genesis needed redating some many millions of years back, roused a storm that, to us, is hardly comprehensible. The geologist claimed a draft on the bank of time amounting to hundreds of millions of years. The biologist supported the claim, even demanding still longer periods for the evolutionary processes he had worked out. Nobody very much minded, for the balance at the bank seemed inexhaustible, and a few hundreds of million years one way or the other were of little importance. Then the mathematician and the physicist waded in, and studied this question of the age of the Earth from other points of view. Their preliminary work was very disturbing, and culminated in the bombshell dropped by Lord Kelvin in 1897, when he definitely stated, that the crust of the Earth was formed "more than twenty and less than forty million years ago, and probably much nearer twenty than forty." Kelvin's masterly calculations were based on the energy losses that a slowly cooling mass like the Earth would have. With scientific caution he stressed the point that he had assumed all sources of energy had been taken into account, and there was no one to challenge this assumption. There seemed no point of reconciliation between the two schools. Against the definite figures of the one side there was but the carefully considered opinion of the other.

Actually a solution of the problem had already been provided, but not yet recognised. In 1896 Henri Bequerel accidentally discovered radioactivity. From his early observations a new branch of science rapidly grew up, which revolutionised our ideas of the structure of matter. We need only consider one little point in this vast field for our present purpose. All the phenomena of radioactivity occur when atoms of a few elements, such as Uranium and Radium, undergo a change which is of the nature of an explosion. During this explosion a certain amount of energy in the form of heat is liberated. This explosion takes place entirely on its own wherever the radioactive material may happen to be; and it was very soon recognised that radioactive material was scattered far and wide through the crust of the Earth. Here was a new source of energy, hitherto unrecognised. At once an enquiry was begun to find out how much heat was liberated during the process and what was the radioactive content of the Earth's crust. Reliable figures were obtained for both these quantities and Kelvin's calculations revised in the light of the new facts. Hence in 1921 we have Lord Rayleigh announcing that "Radioactive methods of estimation indicate a moderate multiple of a thousand million years as the possible and probable duration of the earth's crust as suitable for the habitation of living things." The geologist and the biologist could breathe once more.

The age of the Earth has figured largely as a controversial matter, but somehow it does not seem to be very important in the light of the latest developments to which radioactivity has led the geologists. For some time now it has been recognised that the continental masses of land were underlaid by rocks with a higher density than the continental rocks. The land masses are made of rocks of the granite type, and products of their denudation such as clays. Then there are rocks like chalk and limestone formed by the agency of living matter and left as a memorial of past ages. The underlying rocks are of a type known as Basalts, finer in texture and formed by the cooling and freezing of molten matter. These basalts are heavier bulk for bulk than the continental rocks.

Leaving the unknown interior of the Earth to look after itself, this gives us a picture of the crust, in which we see the continents floating, as it were, in a vast ocean of basalt. It does not matter much that both ocean and its burden are solid. With masses of such immense orders of magnitude we shall get the same kind of relationship as we find in more familiar instances of flotation. The continental mass will sink into the basalt until a stage of equilibrium is reached, in the same way that the liner sinks in the water till the upthrust of the water equals the downthrust of the ship. This balance between continent and basaltic layer has been given the name *Isostacy* which "must to-day be regarded as a *fact* which has been tested by many observations in various parts of the globe and its broad features have never been found to fail."

The full significance of this idea of floating continents has not yet been grasped, and many theories will arise and fall around it. To-day there is one which is attracting considerable attention and is of great interest. Basalt, like the other rocks of the Earth's crust, contains radioactive matter. That is to say, within the basalt there is a continual supply of heat being liberated. When we remember that this sustaining substratum is overlain by either some twenty-two miles of continental rocks or the mighty oceans, it is difficult to imagine that any of this heat can escape into outer space. Even if we suppose that the oceans take some of the heat from a basaltic floor, then this leads us to the conclusion that a colder layer of basalt will be formed in time; and it is estimated that when this has become about twenty miles thick, the heat developed below will be conserved and not lost.

Here we have a new picture, in which we see a layer of the crust at a variable depth, steadily increasing in temperature, as a result of radioactive changes taking place in it, and the inability of the heat so liberated to escape, owing to the protective layer above it. It is obvious that if this accumulation continues there will come a time when the temperature is just enough to soften, and finally melt, this layer. "If the basaltic substratum was at any instant at or near its melting point, but in the solid state, then in some twenty-five to thirty-five millions of years it must inevitably become liquefied as a result of accumulated radioactivity."

When such a change did take place it would be accompanied by changes of density in the basalt, and this would upset the balance referred to above between the continental masses and the substratum. The liquid basalt is lighter than the solid form, and so the continents would sink further into the substratum to restore the balance, resulting in the seas flowing in upon the land. Then, as it melts, the basalt increases in bulk and the strain set up would result in the fracture of the land and the outpouring of vast masses of liquid basalt through the openings formed. Further, in the liquid or semi-liquid mass resulting from this fusion, tidal effects would occur, causing a westerly drift of the continents. This should be greater in equatorial regions than elsewhere, giving a westward bulge to the continents in these regions. Looked at in another way, this drift would cause the ocean beds —still cold and solid—to change places with the continents relative to the underlying layer. In this new set of conditions the loss of heat into outer space would be greater than its evolution by radioactive change, and so a general cooling would take place, with a reversal of the phenomena. The substratum would solidify, the continents rise, and the waters flow back again, leaving a vastly changed land surface, for the forces of denudation to carve into hills and valleys during the course of future geological ages.

Such is the forecast that the modern geologist makes for the future history of the surface of this Earth. It may not be entirely correct as to details, for there may still be undiscovered factors that will modify it. Still the fact remains that the basaltic layer beneath us is, in our own day, somewhere at its melting point. Some thirty odd millions of years hence we may expect a world revolution such as outlined above, and the evidence of the past, as exhibited in the geological record, lends support to the idea. We know that the most ancient rocks—once believed to be the first crust formed on a molten globe—have revealed remains suggesting a period of activity and of life ages before these rocks were formed. Possibly they but represent the residue left from a former outpouring such as this theory suggests for the future.

What may happen thirty millions of years hence may seem of small practical importance in the twentieth century. Still it does give us a picture of cosmical history of great grandeur. Even that tiny planet the Earth assumes a higher place in the calendar of eternity. No longer need we think of the globe as a dying planet, slowly cooling down to a stage where life would cease and the desolation of death be over all. On the contrary, we see our world of civilisation having run its course, " perishing in floods of fire " and, from the debris, a new world being born, a new era beginning and running its course in the same way. The Earth rejoices in the gift of perpetual youth, rising, like the Phœnix of old, from the ashes of itself.

CHAPTER III

MULTUM IN PARVO

"VICAR'S DAUGHTER. *Well, John, what did you think of the lecture on the Atom last night?*

JOHN. *Never heard sich a pack o' lies, Miss, in my whole life.*"

PUNCH.

IN the year 1720, an eccentric individual had his late wife's jewellery melted down, and from the gold so obtained a ring was constructed. This rather vulgar piece of ornamentation was a massive affair, with a raised buckle and sundry other adornments. For financial as well as sentimental reasons, this ring has been worn by successive members of the family, and the word " worn " may be read in both its senses. The present writer discarded the heirloom recently, because it had become a mere fragile loop, liable to break at any minute; yet none of its many wearers could have said at any moment that they had detected the abrasions, that, in a couple of centuries, had worn away the gold. Each fragment of gold must have been extremely minute.

Again, consider a fountain playing in a high wind. The stream of water with which it is supplied is broken up into a number of smaller fragments by the nozzle. These in their turn split up into a thousand drops, and the wind scatters the spray far and wide as a mizzle of water that is vividly described as water dust. The hardest rocks may be ground to a powder so fine that the unaided eye cannot detect its presence as it floats in the air, unless a stray sunbeam picks out the particles, in a darkened room, as points of light.

Such considerations as these led our earliest philosophers to the realisation that the matter, of which our world is made, is capable of division into the tiniest of particles. At once arises the fascinating problem how far is this division possible? A handful of sand can be divided into two groups, each of these into two more, and the process can be continued until we have but one single grain of sand. If further division is required, then a new process of dividing must be employed. Is all matter, like the sand, divisible down to a certain point and no further, or is there no limit? There is obviously a practical limit set by the fineness of our knives and the power of our microscopes, but a practical limit is not necessarily the limit of our thoughts.

Long ago the conception of infinite divisibility was given up in favour of the idea of a granular structure for matter. Two other qualities, which all matter seems to possess, helped towards this conclusion. Not only can material bodies be easily divided, but it is also possible to compress matter, and all forms of matter are porous to a certain degree. What possible explanation of compression can we offer other than the closer packing of the particles of which it is made? The air in the room in which we are sitting could be squashed up until it would go easily into a teacup. Unless this means that the particles of air have been squeezed more closely together, what does it mean? We cannot imagine that some of the air has been squashed out of existence, because, if we release the pressure, then the teacupful of air expands once more to fill the room; and further, if we perform the experiment carefully and measure the weight of the air under the two conditions we find that it is the same in both cases. A granular structure for matter offers a reasonable and satisfactory explanation for this universal property of compressibility.

When we turn to porosity we find again that we are forced to a similar conclusion. All forms of matter are porous, some most obviously so like a piece of blotting-paper, but all to some extent. The first explanation of porosity that suggests itself, is that the process is a simple mixing of the two things, but when we look into it we see that the process is not necessarily accompanied by an increase of bulk. In some cases, there is no change of volume at all, and even a contraction may take place. We get a vivid picture of porosity if we imagine a tumbler filled with fine sand well pressed down. We know that to this well-filled vessel we can add a certain amount of water, which in our ordinary phraseology would be "soaked up by the sand." We can easily see in this case, our statement that the tumbler was *filled* with sand was a mere figure of speech, and that the added water has merely occupied the spaces between the grains of sand.

It appears at first sight a different proposition when we start with a tumbler full of water. Here we should be inclined to say that the tumbler was indeed full in the complete sense of the word. It is, however, a simple matter to prove that this is not the case. If we add sugar, in tiny portions at a time, then a considerable amount will mix up with the water without any overflowing taking place. We say here that the sugar "dissolves" in the water, but, if we stay to think, it becomes very difficult to find any very great difference between this process and the sand and water of our previous experiment. In the first case the water became intimately mixed with the sand, and in the second case the sugar becomes intimately mixed with the water. Is it possible to give any sound, reasonable explanation other than that which supposes the sugar to split up into tiny particles, and then these particles take up positions between the particles of water? It does not matter, for our purpose, how the breaking up of sugar is brought about or how the mixing is effected. Whatever the causes may be, we may conveniently sum the process up under the term *solution*, but what we observe, all tends to the conclusion that matter is made up of tiny particles, and that any specimen with which we deal is but an aggregate of these particles.

Such a conclusion seems forced upon us as we consider these and similar phenomena. There is an alternative in a refusal to think about the matter at all. We can just state facts and leave it at that, but such a method is not pleasing to the human mind, nor does it make for progress. As we come across the problems of the universe we feel compelled to offer some explanation for them, the most reasonable explanation that can be put forth. This is common sense and the practice of everyday life. If Jones fails to keep an appointment, we at once offer some explanation based on our knowledge of Jones. We say, "I expect he has had an accident," or "He has forgotten as usual," and our future actions we base on the explanation we give. We may be right or we may be wrong, but action is impossible until we have some guidance from an explanation of some kind. The scientist calls these tentative attempts *Hypotheses*, and differs from the non-scientific person in keeping the tentative nature of the explanation prominently in the forefront, and immediately setting about an inquiry which will settle whether the hypothesis is true or not. The hypothesis guides immediate action but until proved right or wrong the correct attitude of mind is well summed up by the Scots verdict of "not proven." It is important to realise that the hypotheses of science do not pretend to either accuracy or permanence. They are the first sensible guesses made towards the solution of the particular problem in hand. Future experiments may confirm, contradict or modify them. Much harm has been done by the popular acceptance of an hypothesis as very fact. They are the best explanation that can be offered at the time, based on what is known. If they survive the first onslaughts of criticism and thereby assume a more permanent aspect, they are promoted to the rank of a *Theory*. The theory is still not fact, it is a guess that has stood the test of criticism. The theory becomes fact only when sufficient evidence has been accumulated to justify this further promotion.

The granular structure of matter was, far back in the days of the Grecian philosophers, put forward as an hypothesis which explained the known facts in a reasonable way. For many centuries it remained but an hypothesis, for throughout the Middle Ages very little attention was paid to scientific matters. Thought on all matters during those dark days was under the influence of superstition and doubtful authority, and it was not until the Renaissance period that any freedom was obtained. Then, in the new light of learning, men set about the re-examination of the universe and the classification of the facts that were observed. These classifications were in the nature of summaries which we know now as the *laws of science*. The word " laws " is unfortunate in this connection, for they are but summaries of past experience and are liable to revision as new facts become known. Strictly speaking, the natural phenomena do not *obey* the scientific laws, in the sense that we obey the laws of the land. The laws merely summarise the way in which we have seen that things happen. From the time of the Renaissance, three centuries of work resulted in the formulation of numerous laws in all branches of science. Those which concerned the structure of matter exhibited such a simplicity that the idea they were but statements of some underlying simple explanation was obvious. The underlying idea seemed to be the old Grecian hypothesis of a granular structure for matter.

It was reserved for the Englishman, Dalton, to promote the hypothesis to the rank of a theory. In 1803 when this step was taken it was known that, considering the many millions of different substances which could be found in the world, a twofold classification was possible. On the one hand, there were substances like the metal iron. Every effort to split this substance up into something simpler failed. Every chemical action to which it was submitted left it unchanged. Other things could be added to it, but nothing but iron could be got from it. Iron seemed to be just iron and nothing else. Into this class could be put a number of other substances, characterised by the fact that they had never been split up into two or more other substances. As a class they were called *elements*. The second class of substances were those which, like iron ore, could be made to yield two or more different substances. From iron ore it was possible to get the element iron and also other elements. Such substances are called *Compounds*. It was realised that all the many substances around us were either elements themselves or compounds made of two or more elements. Thus, water is a compound made from the two elements hydrogen and oxygen; washing soda contains the elements, carbon, oxygen and sodium, and so on. New elements were being discovered and it was seen that, in imagination, it would be possible to take the whole world to pieces by chemical means, and arrange the products in a series of groups of elements, comparatively few in number.

Dalton was considering the relationships which existed between these elements when they combined to form compounds, and was also investigating the properties of gases in general. His work led him to revive, although it is probable that the revival was a new departure as far as Dalton was concerned, the idea of tiny particles as the basic material for all matter. He went a step further by supposing that all the particles, or " atoms " as they were called, of the elements were alike. That is, iron was made up of particles all identical, but different in a recognisable degree from the particles that made up oxygen, and any of the other elements. Combination and the formation of a compound consisted of the union of a small number of atoms of one element with a small number of atoms of some other element or elements. Dalton and his contemporaries set about accumulating evidence in favour of this view, and were so successful that the Atomic Theory was soundly established in a few years, and since those days has been the centre of all chemical work. It is not our purpose to follow the details of this work in any way, other than to point out, that here we have the vague speculations, based on wide observations, made concrete by application to a more restricted field. The subject was nevertheless still only at the theoretical stage. There was no evidence of the actual existence of these atoms or of the other particles, called " molecules," which they formed when united by chemical action. Dalton thought of these atoms as being the ultimate units into which matter could be divided. They were indivisible and indestructible, and the following century of work seemed to confirm his idea. As time went on actual evidence as to the existence of the molecule was obtained, but the most shattering explosions that could be performed left the little atom undisturbed.

Less than twenty years from the enunciation of this theory, we find that the idea of a structure for the atom was put forward. The lightest atom of which there was any information was that of hydrogen, and Prout suggested that all the other atoms were made up of hydrogen atoms, but the suggestion, as then advanced, had to be abandoned; and the structureless atom held the field till the last few years of the century saw the discovery of the phenomena of radioactivity. Radioactivity from very small beginning has grown in a remarkably short space of time into a science which has entered into every branch of scientific inquiry. Its applications have been innumerable, and its results have caused us to completely change our outlook as to the structure of matter. Briefly stated the central fact of radioactivity is the discovery of a structure for the atom. It has been found that the atoms of certain elements split up and form other elements. Thus the atom of radium splits up and forms an atom of helium and another of niton. Here at first sight it seems is a complete contradiction of the Atomic Theory, for such a process indicates that the atom is not indivisible or structureless. It does not matter that this change takes place on its own, and that we cannot in any way influence it at the present time. When however we look more carefully at the matter we see that the assumption of indivisibility is in no way essential to the Atomic Theory. The atom is still the unit of chemical action. Compounds still consist of molecules made up of atoms, and radioactivity has not made any changes in this respect necessary.

Radioactive changes and the various manifestations that accompany them have given us definite evidence of the actual existence of the atom, and thereby promoted the theory to a fact. Before we deal with the light which has been thrown on the internal anatomy of the atom it would be as well to endeavour to get some idea of the size of the particles with which we are dealing. It is very difficult indeed to grasp the meaning of such tiny things as these atoms. We can write figures for their weight and their diameter but the figures have no real significance, any more than the vast number of millions that make up our national debt mean anything other than a burden to the average man. We may find the following illustration helpful, but at the best it can only suggest and not make obvious. Hydrogen is the lightest known element, and its atoms are therefore the smallest known. An ounce of this substance will be too much for our purpose, and so we will begin with one ten-millionth part of an ounce and imagine that it is possible to count the single atoms in this very minute portion of hydrogen. It will prove a very long and tedious job, and so we will enlist help in our task, and employ the whole human race, men, women and children, to assist us. This band of workers, numbering some thousand millions, we will train to count atoms at the rate of one a second, and we will not bother as to how we can parcel out the microscopical amount of hydrogen among them. The word "Go" is given in 1925, and all the rules and regulations of Unions and such-like are broken, for everyone must work day and night, week in week out with never a rest for food or sleep, if the task is to be completed somewhere about the year 1978. Our method may have been devised in the realm of imagination, but our facts on which the above calculation has been made are far more accurate than those which satisfy the housewife buying a joint of meat. In fact we know the weight and size of the atom with a degree of accuracy that equals, if it does not exceed, the accuracy of the figures which we can give for the weight and size of the earth.

Yet it is within these atoms that we have detected a structure, and not a simple structure at that. Ordinary methods of observation fail utterly when dealing with objects of such smallness. The conclusions that have been reached are the result of a combination of chemistry, mathematics and physics. It has been necessary to form hypothesis after hypothesis, and test each one by further experiment until a safe conclusion was reached. At the present time a general agreement has been reached as to the main structure of the atom, although the details are in dispute. The atom is constructed more or less on the plan of the solar system. Situated somewhere at its centre is a comparatively heavy mass, called the *nucleus*, and around this are scattered a number of planets called *electrons*. The most disputed point is the arrangement of these planetary electrons, one school supporting the idea that they revolve around the nucleus and the other that they are more or less fixed or vibrating about fixed points outside the nucleus. The nucleus itself has also revealed a structure, and consists of a mixture of electrons and other particles called *protons*. Further, the electrons and the protons have been shown to be little bits of electricity. To those of us who have been accustomed to think of electricity as a force and not a material substance this conception is a very difficult one, but it is one to which we must get accustomed, for it is based on experiments about which there is no doubt. These new views of the atom paint a picture of matter that is wonderful in the extreme. The nucleus and the electrons are still more minute than the atom, measurements of which are really the measurements of a collection of things. The analogy here to the solar system is very useful. We can speak of the diameter of the solar system, and of it moving as a unit through stellar space, but at the same time we see that the units of which it is made up occupy but a fraction of the space covered by the whole system. Similar considerations hold for the atom. Most of it is empty space in which the electrons move or vibrate. The solid rocks on which our habitations are built, the buildings themselves, our own bodies, in fact, all matter is more empty space than anything else, and that little else is made up of tiny bits of electricity.

As we have already stated, we are quite unable to influence by any known power the structure of the atom. The definite arrangement of the nucleus and its electrons is a state of equilibrium that refuses to break down at our command. With the few radio-active elements this equilibrium is breaking down of its own accord into presumably more stable arrangements. Our study of this *disintegration*, as it is called, will doubtless give us in time the means required to bring about the change when we so desire, but that time is not yet. At present we must be content with the very majestic view of nature that these discoveries have provided. In the heavens above us we see mighty systems of stars, the size of which once staggered our imagination, and now in the dust at our feet we find systems equally complex and equally staggering in their minuteness. We cannot but marvel at the economy of method, for in the starry system and the atom Nature is but keeping together certain portions of the Universe, and the basic principle of both is the same.

CHAPTER IV

THE FORCES OF NATURE

"*Thinkest thou there is aught motionless, without force and utterly dead.*"
CARLYLE.

OF all the marvels with which this world impresses us, none is equal in magnitude to those manifestations which we call the forces of nature. The most lasting impression is given when in a mood of prodigality Nature pours forth energy as though the supply were everlasting. The tearing flash of lightning, the roar of the thunder, the raging hurricane, the blinding heat of the volcano, the devastating roll of the earthquake, the rushing avalanche and many another outpouring of energy, leave us helpless before mighty forces that we can neither control not direct. The very word "force" itself suggests something overpowering and majestic, yet we recognise that giants may sleep and have their playful moments, but it is as giants we see their sleeping forms.

At other times we recognise these same forces at work in gentle moods. The soft zephyr fans our faces with a cooling breeze, the tiny trickle of water quenches our thirst, the mellow warmth of spring awakens life from its winter sleep. Whether we think of Nature roaring like a lion, or cooing like a dove, we are still impressed with the wonder and the majesty of her forces. The subject lends itself to vivid description. It has inspired the poet and the painter to some of their finest efforts, and even when we leave the realm of art and try to gain a glimpse of the scientific aspects of these forces the wonder is but increased. Certainly we are met early in our inquiry by the formal notice boards of the scientists. "Here is Mechanical Force," "Here is the force of Gravitation," "Here is Electricity" they say, and that is about as far as they do go. These notice boards are really nothing but names. We know very little of the real meaning of forces, although the classification of the notice boards is a necessary preliminary step in our inquiry, although it may be a long way from the end.

As we think of the forces of nature we see that each of them is associated in some way with matter, which justifies their consideration under the title of this book. It is this association that will be our main consideration here. Manifestations of energy arise in connection with some material portion of the Universe. It is the inert form of the horse that can awaken into activity, and whose energy can be put to useful mechanical purposes. The soulless mass of steel and wire can be made to generate supplies of electricity for use in our workshops. The lump of coal transforms the fire-box of the locomotive into a chemical laboratory, and releases its chemical energy as heat. Green plants can trap the sunlight, and utilise its energy to build up their complex bodies. The waterfall can drive the mill, and one and all begin with matter.

Then we realise the interchangeability of the various forms of energy. In a past age strange fern-like plants trapped the energy of the sunlight, and stored it up in their tissues, locked up as chemical energy. Other ages piled rocks on the rotting vegetation of those days, and we in our time dig up the product and call it coal. Its chemical energy we release as heat in the steam-engine, which is made to drive the dynamo and so generate electricity, which streams away to work a lift, light a room, heat an oven or send a song by wireless. It matters very little where we start or which way we go, we can ring the changes as we please and pass from one form of energy to another with comparative ease. The force of gravitation, which is the mutual attraction existing between any two bodies, is likewise interchangeable. A weight suspended in the air can be made to fall under the attraction of gravity and in so doing made to work a machine, which in its turn can be made to provide other forms of energy. Another machine, which works only when supplied with energy, can drag the weight back to its original position and give it once more its power to do work, in other and more precise words, can restore its potential energy—energy due to its position. We must not omit either that elusive form of energy which we call mental energy. It may be doubtful if we really know of what we are speaking when we talk of mental energy. In some vague way we feel behind our lives some mental urge to be up and doing, and the energy analogy is too convenient not to be utilized. We speak of periods of mental activity when we expend mental energy, but exactly the significance of that word "mental" few would care to define except very provisionally. Further knowledge may possibly bring this energy into line with the rest.

We are led to wonder whether in reality there is but one source of this strange quality that we call energy. Is it possible that our classification is based merely on faulty observations in which we recognise the same thing by different sense impressions? We know that the extension of the study of electricity has revealed a similar faulty observation of energy manifestations. Electromagnetic waves now include, in one simple view, a long list of forms of energy at one time considered to be distinct. Magnetism, electricity, heat, light, X-rays and all the other manifestations that we group together as radiations are, we know, but manifestation of one and the same thing. Possibly the future may see a further extension of this simplification, and all the forces of nature may be included in one grand yet simple view. Towards such a simplification we have certainly moved recently, a movement that will be considered more in detail in the next chapter. In the new outlook of Relativity we see the forces of nature replaced by rather uninspiring mathematical equations, and we are led to doubt even the reality of their existence.

Possibly the older view of looking upon the forces of nature as something very real, and the newer one of considering them as geometrical necessities are but two ways of looking at the same thing. There is a continuity in the history of scientific progress that is often missed. Great names are associated with the discovery of this or that fact or the enunciation of this or that theory. We are apt to date progress by these outstanding discoveries or advances of theoretical considerations. When we look more closely at the matter we can see that such discoveries and inventions were more or less necessities at the time, and the men mere accidents. As Lord Haldane has said, "We are too prone to read the history of philosophical knowledge as though it consisted of a record of mere corrections of error and supersessions of defective opinion. In reality it is the history of advance in ideas which have been revolutionary mainly in their expression." As we see it, the progress of science has been very much like a journey up a spiral staircase. At every turn a new view of the old landscape is obtained and each new view comprehends a wider horizon. The contribution of each age is the description of the view as seen. Some ages have raced up the steps, while others crawled slowly step by step, but at each stage the view was inevitable.

The history of the study of the forces of nature illustrate this idea very clearly. Thus, for example, early Man viewed the lightning from the level of the ground and was appalled by its fury and might. From a slightly higher level Gilbert described the foreground of the view. Franklin reached the level of the thunderstorm and tamed the flash. Faraday reached a higher level still, and saw peaks stretching far away. Maxwell made out the whole ridge of which the peaks were but isolated facts, and Einstein has described a view not of a single ridge but of a whole mountain system in which the science of electricity is linked up with the whole domain of natural science.

When we realise also that the main activity of living matter is the obtaining of energy, its storage and utilisation as required, we can appreciate the marked attention that has been given to the conquest of the forces of nature. Every animal and every plant depends for its life on the maintenance of this supply of energy. "We have now learnt to look upon an animal or a plant as a complex and extremely delicate piece of machinery, constantly employed in collecting energy directly or indirectly from the sun's rays to maintain an incessant struggle against the destructive forces of its environment." "Life like a flame is a manifestation of energy."

The plant has learned to take its supplies of energy from the sunlight. Through the medium of its green colouring matter it traps this energy and uses it in the formation of complex chemical compounds, manufactured from very simple raw materials derived from the soil and the air. The animal picks up the process at this stage, and consumes the plant and its store of chemical energy. The compounds of the plant are broken down into simpler ones by the living mechanism of the animal, and the energy freed in the process, and used to maintain the animal's body at a temperature above that of its surroundings and to provide the motive power for its bodily and mental activity. Carnivorous animals, of course, feed upon others which have built up their bodies from the plants, and thus we trace all the energy of animal life back to the rays of the sun.

There is a very delicate balance in this energy circle, in which the needs of the plant and the animal are kept in equilibrium. Under natural conditions a world of plants or animals alone is an impossibility. Man, however, has not been content with this simple arrangement. His view of life craved for a greater supply of energy than the needs of the moment or his own animal requirements demanded. Around him he saw the prodigality of Nature with energy to spare and going to waste, and he set out to capture these supplies and bend them to his own uses. He seized the waterfall and the flowing stream and made them turn the water-wheel to grind his corn. In later ages this utilisation of the energy of falling water has been extended to an enormous extent, as is instanced by the vast power station situated at the foot of the Niagara Falls. The winds, resulting from the unequal distribution of energy in the form of heat, he made to turn the sails of his windmill and water pump, and to drive the wooden craft of past ages across the waters of the world. Fire has been put to innumerable uses, and the energy stored by plants in past ages has been dug up from our coal mines. Over a thousand million tons of coal were mined in 1924. Petroleum has been found in huge supplies, of doubtful origin, and made to yield a rich harvest of energy. Man has copied the lightning in the manufacture of electricity and by its aid "we switch on the light; we use the telephones; we listen-in to the wireless concert; we travel in electric lifts; our trams and trains are run by electricity and at every touch and turn electricity enters into our lives."

Yet of all these supplies of energy available for the use of Man, one only, that provided by plant life, is more than a temporary supply. Vast coalfields may yet be discovered, further deposits of petroleum may be found, but the store is not inexhaustible, and we are dipping very deeply into our credit. Our water power must reach a limit beyond which it cannot pass. We may harness the tides in the future and we may even learn to use the thunder clouds, but to all these there is a limit. To-day practically every scrap of energy that we use is derived from coal or oil, and without this supply the whole fabric of civilisation would fall into ruins. In the future we must find some other sources of energy than those at present available.

At the beginning of the present century no such additional source was in sight, but the new science of radioactivity has indicated a direction in which research may be profitably employed. A few rare elements were discovered which were found to be undergoing a remarkable change. The atoms of which they were composed were continually splitting up and giving out energy in the process. Confining our attention to the best known of these elements, Radium, we find that the atom of radium breaks up with explosive violence into two other atoms, helium and niton respectively. The niton in its turn, undergoes a similar change and the process is continued till an end-product, supposed to be lead, is obtained. During this disintegration, energy in the form of heat is liberated. The extent of the liberation may be gauged from the statement that "radium furnishes 250,000 times as much energy as is given by burning an equal amount of coal." Here, indeed, is a fascinating prospect, but fact compels us to state that there is little hope of the practical utilisation of this energy. Radium and the other radioactive elements occur in only very small quantities scattered through the other rocks of the Earth's crust. Their isolation is a difficult and expensive process, and when they are obtained the disintegration is a slow process, and the liberation of energy is likewise slow. So far we have entirely failed to effect any modifications of this radioactive change. It just proceeds at its own appointed rate, and is not influenced in any way by any forces that we can bring to bear upon it. There seems very little hope that we shall ever be able to bring it about at a quicker rate or find huge supplies of radioactive material anywhere in the crust of the Earth.

However this manifestation of energy in such vast quantities, even if occurring over long periods of time, does suggest that associated with matter are stores of energy vaster than any with which we have hitherto dealt. The further study of radioactivity had indicated also that these supplies are in some way associated with the tiny atom. This stable little aggregate of still smaller particles has locked within it stores of energy that stagger imagination. We cannot unlock this storehouse at present. We know of its existence, yet stand before it powerless, much as did our prehistoric ancestors confronted with a forest conflagration. That the search for the key will be well worth while we cannot doubt, for a thimbleful of apparently dead matter may contain as much energy as we obtain from three thousand tons of coal by ordinary processes!

Very little progress has been made in this search so far, despite the rather blatant advertisement of coming experiments and the accompanying humorous newspaper comment. In fact, the greater the advertisement the smaller the result seems to be a general rule.

Those who are genuinely trying to solve this problem will not be at all likely to blazon forth either their intentions or results until such time as they rest on a much surer foundation then can be afforded to-day. At the present time we do not know the full story even of the internal structure of the atom, and till that is known anything in the nature of success in splitting it up must be just blind luck. Progress by blindly blundering along is not characteristic of science. Still we may look forward to a time when more complete knowledge will yield the key to this huge store of energy and show the way to liberate it and control it. Then Man will be provided with an instrument for progress such as never before has he held, and may wise counsel and sane judgment be brought to bear in that day on the use of it.

CHAPTER V

THINGS ARE SELDOM WHAT THEY SEEM

"*I don't understand you,*" *said Alice.* "*It's dreadfully confusing!*"
"*That's the effect of living backwards,*" *said the Queen kindly;*
"*it always makes one a little giddy at first.*" LEWIS CARROLL.

WHEN little Buttercup told Captain Corcoran that "things are seldom what they seem" he was duly mystified, and possibly his state of mind may be taken as typical of the majority of us when that vexed question of Relativity comes up for discussion. It is not proposed to devote much space here to yet another attempt at explaining, in popular language, Einstein's brilliant contribution to an age-long problem. This has been done, and well done also, in many books and numerous articles and yet the understanding eludes all but the few. Perhaps it is an impossible task, and perhaps the failure to make relativity understandable is due to insufficient preparation of the ground on which it is proposed to sow the new seed.

Einstein's theory dives very deeply into the problems of the Universe, and is no easy matter that can be followed and grasped in a few minutes. Even in the highest ranks of scientific workers, its tenets are still centres around which hot controversy rages. Even as we write, claims are being considered for experimental evidence that, if accepted, will seriously disturb the relativists. After all, Einstein's theory is but the latest contribution to centuries of thought, and it may conduce to clearness if we try to outline the work that led to its formulation.

Where may we look for the first beginnings? Possibly, if only in imagination, we may take our stand by that being who first was Man. At some time in his history he would watch the starry heavens with the wondering "eye" of a dawning intelligence. In his primitive mind we can picture the first voicing of the old nursery query—

> ". . . little star;
> How I wonder what you are?"

We can fancy the satisfying of his wonder by vague and tentative speculation from age to age, increasing in content with the development of the brain and the widening of observation, till we reach the myths of dim civilisations long forgotten. Later we see the master-minds of ancient Greece, and their followers, collecting the scattered data and giving it a measure of precision in their philosophical treatises.

We picture Euclid puzzling out a logical system of geometry, from the foundations of what seemed to his age to be simple home-truths. His system is seized upon by a practical world to serve the useful purpose of surveying—a practical world that cared not one iota whether the foundation was truth or illusion as long as it was useful. Centuries pass till the vague speculations of the past are given that precision that only a mathematical mind can bestow. Newton evaporated the dilute solution of speculation, and so crystallised its contents in definite forms. In describing his results he accepted the home truths of Euclid. In this way he was able to set out the laws of natural phenomena in simple statements. The puzzling movements of the heavenly bodies were reduced to comparative simplicity by Newton's *Laws of Motion*.

Newton envisaged a vast, and possibly endless, space, in which massive suns and planets moved in accordance with the Law of Gravitation—the law of their mutual attractions. Such was his theory and it is wise to emphasise the fact that it was a theory. Indeed it is obvious that every conception of the Universe that the mind of man may devise, must remain a theory until it has been tested against *all* experience. Every atom, every giant star, every true thought must be brought within the theory before it becomes final fact. While yet a single speck of the Universe remains outside, there is always the possibility that just this one speck would be the exception that did not prove the rule. We are a long way from that final stage yet.

Newtonian space was almost too simple. It failed because in certain respects it left the mind of man unsatisfied. Away on the sun, millions of miles across empty space, events took place which had an effect upon the surface of the Earth—light travelled, with definite velocity, across this space. How could such a passage occur if the space were empty? Newton met the objection by supposing that light was a stream of small particles shot out by the sun, but the explanation failed in the light of precise experimental evidence. These specks refused to come within the theory, and so modification was necessary. Huygens suggested and Young established a theory which filled all space with one continuous "jelly"—the luminiferous ether—endowing it with wonderful properties. Light became a wobble in this jelly, and was propagated by a train of waves. This quasi-material jelly, in its turn, had to give way to the more abstract, but more satisfactory, electro-magnetic ether with which the famous Clerk Maxwell tenanted space. Maxwell did for light and electricity what Newton did for gravitation and motion. Building on the experimental work of Faraday, he simplified observation into the concrete form of mathematics. His work led him to invent the idea of electro-magnetic waves, of which he showed that light was one form. The phenomena of these, so far hypothetical, waves he expressed in the famous Maxwell equations—still based on a Cartesian geometry, which Descartes had, before the time of Newton, developed from the primary postulates of Euclid.

Theories must always wait the confirmation of experiment and Maxwell's predictions were verified—less than forty years ago—by the masterly researches of Hertz, who performed in 1888 the first wireless transmission, covering a few feet only, using the electro-magnetic waves that Maxwell had said were possibilities. At this stage of progress, the ether in which these electro-magnetic waves were supposed to work, seemed to possess a definite velocity in space. It was a moving ether which, along with the solar system, was tearing through the confines of space. Once more a fundamental conception such as this failed to satisfy the practical researcher, and an alternative was adopted in which the ether and matter were divorced and the sun and its planets imagined as tearing through the ether.

We can recognise the value of these theoretical speculations, for we see how they assisted progress, but at the same time we cannot fail to see that in the case of this fundamental ether there were numerous difficulties. With increase of facts it became necessary to make one assumption after another about the properties of the ether until they became as cumbrous as the string of names bestowed on Royalty at baptism. One crucial consideration arose and demanded satisfaction. Whatever the nature assigned to the ether, whatever structure we give to matter, it did seem that experiment should be able to detect the drift of the ether as the Earth tore through it. It was possible to devise experiments for this purpose, but when they were performed the results were always negative. A tiny cloud obscured the serenity of the sky—*Was there such a thing as an ether at all?*

Mankind—even including the scientist—is wisely conservative by nature and does not willingly forsake any position unless the alternative is obviously sounder. The only alternative to a moving or stationary ether seemed to be no ether at all, and how in the name of fortune natural phenomena were to be explained as happening in empty space was beyond comprehension. Hence we see the invention of still further assumptions to account for the failure to detect experimentally the ether drift. Blind faith was almost at times required to accept these explanations. It seemed as if the ether were playing a mighty game of hide and seek in the world of science. Always at the critical moment it eluded actual capture, leaving, like the Cheshire cat, a spectral grin to mock its pursuers.

The position was wellnigh intolerable when into this somewhat confused field Einstein introduced his *Special Theory of Relativity* in 1905. Although his suggestions did not attract very much attention at the time, the importance of his ideas gradually gained weight. Ten years later his early efforts were carried a step further and the *General Theory* was enunciated. This extension was an attempt to grapple with the whole problem of the Universe. It was revolutionary in its significance, it boldly attacked the preconceived idea and arrayed the scientific world in the panoply of wordy warfare.

Let us briefly, so briefly as to be in deadly peril of the unforgiveable sin of dogmatism, survey the position as it stands to-day before we pass to other considerations. Before Relativity came, we thought of space as filled with an ether, in which matter moved, being impelled so to do by the forces of nature. These movements conformed to the statements known as the laws of motion and gravitation, and for the electro-magnetic forces the Maxwell equations gave all the necessary information. Space was like a great box—perhaps with unending sides—containing a very ingenious clock-work toy, all wound up and made to work. Each separate part of the toy moved through its appointed part of space in a given time, with a history behind it and a future before it. Time streamed past us, the observers of the toy. Such was the theory and it was hoped that in time we should understand all the complications which we watched.

Relativity is another theory, which provides a means of describing the physical universe in the precise language of mathematics. This description not only omits all reference to any kind of ether, but it abandons also the forces of nature. Such a position is made possible by postulating that all motion is relative, a conception which gives a new meaning to space. An event in this new space has not only a position in space, but also a position in time. The older theory constructed a universe in three dimensions—length, width, and height. The new theory adds a fourth—time. A point exists in time and space, and its position is given by its four dimensions, a position stated only by the use of mathematics so abstruse as to be beyond all but a few specialists. A new four dimensional space is conceived in which matter moves along natural paths. A bowl follows a curved path as it rolls over a level green, not because it is attracted by some force dragging it towards the edge, but because the curve is its natural path. In the time-space of Relativity, the Earth moves round the Sun, because that is its natural path—to speak of the attraction of the Sun for the Earth is an unnecessary complication of the description of what is happening. The natural paths are determined by the geometry of the four dimensional space in which they occur. They are "geometrical necessities," in a geometry wider than the home-truths on which Euclid and Descartes tried to describe space.

For such geometrical necessities, the postulation of an ether is not necessary; if it is necessary for the peace of any minds it may remain, but still things will happen as if it did not exist, which is more or less what the older experiments proved. Forces are also unnecessary, and we are left with a conception of a strangely contorted space in which events happen because that is the natural outcome of the conception. The thorough-going relativist makes no attempt to construct a model of this new time-space, because he has realised that such a task is impossible; the relationship between his work and what the average mortal calls reality does not concern him. We will leave the mathematician and the physicist to sink or swim in Einstein space and turn our thoughts in other directions.

The average mortal whose mathematics is but a memory of the soul-deadening thing that masquerades in our schools under this title, has long given up any attempt to follow the details of the relativists. Still it is recognised that big things are afoot and the query naturally arises as to whether there is anything in it that can be made to fit into the mundane events of the everyday world. Is there anything that the average man and woman can apply to the problems of daily life? Has Relativity any meaning for the progress of Mankind? Frankly, it must be admitted that a definite answer is very difficult. We are too near the beginning of the idea to appreciate its full significance. But there are certain aspects that are worthy of emphasis and which, in a way, give a partial answer to these queries.

Underlying the theory, as it is usually discussed, there is a general principle—the principle of relativity—of which we all possess a more or less vague idea. If we stop to examine our words critically we know, for example, that the sentence " I saw a big animal " has no real meaning to anyone other than ourselves. The biggest animal on the continent of Australia is the kangaroo. " Big animal " would have a very different meaning for the Australian aborigine than for a native of the interior of Africa, accustomed to meet elephants and hippotami. A " long " walk for me may mean ten miles, but to the practised tourist ten miles is a mere flea-bite. A century ago the " Victory " was a mighty ship, to-day it is a cockle-shell beside an ocean liner.

All our measurements are but comparisons; even when we give them a precision and say that a cricket pitch is twenty-two yards long, we are only stating a comparison with a unit known to ourselves. The statement would be meaningless to a Pygmy of the Congo forests. Our forefathers were justly proud of a journey from London to York in two days—weather permitting. We should grumble if the Flying Scotsman was fifteen minutes over its four-hour schedule time, and we say that our suburban trains " crawl " along. The aviator even pities the man in an express train.

If we turn our attention to our measurements of time we detect a similar characteristic. Time " flies " when we are on our holidays, it " drags " when we are bored. Except with the aid of a mechanical device we have a very vague idea of the passage of time. We recognise day and night, we make for a meal when we feel hungry, but who would trust to feelings to keep an important interview.

The huge block of wood, under the weight of which we stagger along, becomes so light in water that we can manipulate it with one finger. If a mermaid were given a spring balance and used it to determine the weight of a block of stone on the floor of the ocean, she would get a very different result than we should with the same balance and the same stone on the seashore. Why should we consider that we are right and the mermaid wrong, because if we carry the stone to the top of a mountain we shall get still another value for its weight. There is no reason to give to any one set of conditions an intrinsic rightness more than to any other set. Measurement is relative, every measurement is right for the conditions under which it is made, and for those conditions only.

If we turn our attention to more complicated examples of measurements, then by mathematics based on the Theory of Relativity we become more uncertain about the matter than ever. It can be shown that the length of a measuring rod will become less, a clock will go fast, the mass of a body increase, if the rod, the clock, and the body are in motion. Motion even itself is relative; its is only the rocking of the train that tells us that we are moving, and that the telegraph poles are not flying past the carriage window. If the train flew off the edge of the Earth and travelled through space, we should have no knowledge of our movement, because we should have no background against which we could refer our experience.

If these things—our measurements—which seem so sure and certain, rest upon so insecure a foundation, surely there is a lesson of caution to be learned. Our whole attitude towards the problems of life must be one of extreme care, for the conclusions of which we feel so certain may have only a relative value against the framework of the present. Our outlook on the Universe is a relative one, which the common-sense person will at once point out does not need an Einstein to announce. What Einstein did was not to point out this elementary truth, but to provide a method, based on it, for giving a mathematical description of the phenomena of the Universe. He emphasised relativity and applied it in particular directions.

The application has been fruitful, whether the details that scientists are now examining finally confirm the theory as it stands or call for radical modifications. We have been forced to review the work of science from a slightly different angle, and rearrange the data on a new structural plan. Revision, entailing fresh examination, is always of service, and in this case certain physical problems that proved of difficulty have been successfully solved along the new lines. Relativity has stimulated many branches of science and served the further purpose of breaking down the barriers that grow up between the various fields of research. Particularly has this been the case with the relationship between science and philosophy. It has forced the philosopher and the metaphysician to approach the chemist and the physicist and conjointly take their respective skeletons out of the cupboard and see if some of them can be scrapped. The philosopher claims the whole world for his province; it is his task to make the final model from the bricks supplied by the workers in other limited fields. Unfortunately he speaks a language that when he really gets going convinces the ordinary mortal of the wisdom of the heathen Chinee, who is said to believe that the best thing to do when it is raining is to let it rain. Relativity is helping towards the establishing of a philosophy that has some relationship to common sense.

The background against which the student of science works has been changed. We cannot help but think that such a change, even if it is but a temporary one, will prove a step forward towards that ultimate goal of complete knowledge. What to-day may appear puzzling, and remote from mundane affairs of life, may at any time become startlingly clear and vividly illuminate every walk of life.

CHAPTER VI

PRIMORDIAL MUD

"I am, in point of fact, a particularly haughty and exclusive person. . . . I can trace my ancestry back to a protoplasmal primordial atomic globule."
POOH-BAH IN THE "MIKADO."

LIVING matter, and Man in particular, is constantly striving with the inanimate forms and forces of Nature. Ever it seems to be seeking to know and control, displaying in the battle a spirit of endeavour which at once maintains the fight, refuses to accept defeat and adds a fascination to the study of life which appeals irresistibly to us all.

When, however, we turn our attention to the living organism we find ourselves confronted with problems of deep significance, many of which are unsolved to-day. The study of Man—" the proper study of Mankind "—leads us to the other animals, through them to plants and on to the most primitive and simple forms of life. Beyond the records existing to-day and found in written history, the story is told in the fossil remains of past ages. Despite notable gaps, where whole pages have been obliterated by the changes in the Earth's crust, we now possess a fairly concordant history of life on the Earth.

History, however, tells a story of succession, but it is the relationship between the succession that is receiving attention, and proving a problem bristling with difficulty. The background of this problem is the dead crust of the Earth, which at some time just prior to the appearance of life could be described as " a monotonous smoking desert, cindery under foot. Here and there out of a crack a sluggish crawl of molten rock, like a very coarse-grained tar, hardening and blistering on the surface as it cooled, and creeping out from the dust in an ugly way. No sun by day, no moon by night, but a thick curtain of cloud over everything. . . . There was no sign of life, nor any sound save crackling and hissing and now and then a bomb."

Since that time Life has been added and in the ages that followed the dreary wastes have been clothed in the verdure of plant life, the movement of animals, and all the beauty of colour and form to which we give reverent admiration.

The history of this life, exhibiting differences such as between the dragon-fly and the elephant, the oak tree and the buttercup, take us back through ages of simplification. From whatever angle we study the story, we see that simple things precede complex ones; and we are forced to the belief that we are unravelling what was a story of evolution. No serious opposition to that statement exists to-day. Evolution is accepted as a fact, which can still be defined in Darwin's own words—"The innumerable species, genera and families of organic beings, with which the world is peopled, have all descended, each within its own class or group, from common parents, and all have been modified in the course of descent."

The acceptance of evolution as a fact is the result of centuries of thought culminating in the great forward strides made at the beginning of the last century, and reaching a climax in the carefully classified contributions of Darwin. Evolution, however firmly established, does not offer an explanation of life itself. It does lead, as we shall see, to what we may consider the most reasonable interpretation, but its main function is to explain the development of the complex from the simple, and so to account for the variety of life as we find it on the surface of the Earth.

Prior to evolutionary doctrines we have very little of scientific merit to guide inquiry. Mankind included life in the conception which attributed all that happens in the Universe to some external agency, a God or many Gods. The earliest histories and the most primitive races now existing have their sagas of "creation," so highly developed as to suggest an origin dating far back into pre-history. The creator theory is in no sense an idle speculation which can be contemptuously dismissed. In our own time the vast body of educated thought has passed beyond the very materialistic stories of modelling in clay, but we can be whole-hearted evolutionists and yet believe that the Universe is part of the design of a Master Mind, whose methods it is the task of science to investigate. The theological aspect of this subject is too vast to be discussed in brief, and if we give it but short notice here, it is not that we lack appreciation of its significance, but that our task lies in other directions. *The creator theory makes change and variety part of the unexplained plan of God.*

We must also note that as early as the Grecian philosophers, two schools of thought can be distinguished. On the one hand, we have Aristotle teaching that life is as much the subject of law as the motions of the sun and the planets, and, on the other hand, his opponents claiming that life is a matter of chance. The latter school has predominated throughout the ages. Darwin and his followers are the flowers of this school, for they supposed that Nature might produce a thousand varieties that one should survive. To this aspect of the subject we shall return in greater detail in the next chapter on Inheritance, contenting ourselves here with the statement that a broad survey teaches us a wise caution. The last word has not been spoken on either side.

Granting that at some period life came to the Earth, the query at once arises whether this addition was something entirely new, or was merely an extension of what existed already. Again we can recognise two schools of thought. There are those who see in life something unique in the Universe, a quality that defies precise definition, yet is easily recognisable. This school of *vitalism* points to the behaviour of even the simplest of living things, which exhibits characteristics difficult to explain other than as purposive. Life, they say, strives towards an end, directed by some influence—the unique vital principle. No attempt is made to say what this vital principle is.

Opposing this school are those who see in life nothing but the manifestations of the laws of chemistry and physics. To them the living organism is as much a mechanical structure as the crystal, much more complicated of course. They point to the fact that a century ago it was believed that the materials, of which the bodies of living matter are made, were formed as the result of a vital principle, and that since then the chemist has shown that he can make these self-same materials in the laboratory, without the agency of any living thing. Year by year we become more acquainted with the chemistry and physics of life, and realise the importance of this and that action for its maintenance. By chemical manipulations we can modify the processes, and the hope is expressed that in due time biology, the science of life, will become but a branch of the older sciences, and life be expressed in the formulæ of chemistry and the symbols of mathematics.

Neither school has proved its point beyond dispute, and possibly there never will be reconciliation; for, given the formulæ and symbols, it will still be possible to treat them as the expression of the ways of the vital principle. Realising these inherent difficulties we may still turn our attention, with profit, to speculations as to the origin of life. Here, indeed, all is speculation, but we may reasonably suppose that our guesses are nearer the truth than those of the past. A vast literature exists on this subject, and we can only consider a selection of views that have aroused most attention.

Again we must note the stories of "creation," in which life, as we know it, was produced fully formed; with the later and more acceptable modification, the creation of some primordial form from which later varieties have evolved. Such creation stories are always set in the far distant past, for, as far as we know, living matter is not being produced to-day other than by the normal processes of reproduction. This does not deny the possibility of continual creation in some minute form that, so far, has escaped attention. By the very nature of the theory, it is matter more of belief than of scientific demonstration.

We must also refer to the very old idea which is crystallised in the words "spontaneous generation." Aristotle taught that fully-formed living creatures could be formed from pre-existing dead matter. Decaying organic material soon swarms with living forms, moulds grow on damp bread, beetles and maggots appear in putrid flesh, and even a glass of water, left exposed to the air, becomes the home of a myriad, microscopic creatures. What more natural than to suppose that the lifeless bred the living. Such was a common belief, even in scientific circles, until the Italian, Redi, in 1668, indicated that no such appearance of living matter was seen, if precautions against infection from outside sources was taken. Redi was the logical forerunner of Pasteur, in whose hands the science of antiseptics was established, on such firm grounds, as to kill the conception of spontaneous generation for all time.

A very clever suggestion for the introduction of life on this planet, is that which would derive it from some outside source. We know that some forms of existing living things can survive the most intense cold to which we can expose them in the laboratory, and we have very good reasons for believing that these temperatures are near the limit of coldness that can be reached in any part of space. There seems, therefore, to be no very valid objections to the supposition that minute forms of life could reach the surface of this Earth, from outer space, either as passengers on meteorites or by other means. Such germs, arriving at a suitable period in the history of the cooling surface, would revive, multiply and provide a basis for future evolution. It is, as we have said, a clever explanation and a feasible one as well, but as we reflect over it we find that it fails to satisfy. It may account for the life on this globe, but it offers no explanation of the origin of life itself. Indeed all that it does is to remove the problem from the Earth to some other spot in space where its solution becomes even more difficult.

The development of living matter, from existing materials under suitable conditions, offers the most profitable field for scientific speculation, whether such conjunction of materials and conditions is considered as happening fortuitously or as part of the plan of a Creator. Chemically the idea is capable of satisfactory presentation. The lifeless materials, of which the surface of the Earth is made, consist of innumerable different substances. The chemist has succeeded in splitting these many substances into a comparatively few simpler ones, called the elements. Lifeless, or inorganic matter, is made up of compounds of the elements.

This analysis of matter has been carried still further. The elements have been shown to consist of tiny particles called atoms, which in their turn are built up of still more elementary particles of electricity, that we know as electrons and protons. We are beginning to realise, rather vaguely at present, that this analytical process is, in all probability, the reverse of that by which Nature evolved the Universe. We can imagine a time and conditions when the electrons and protons were free and uncombined. As conditions changed we may suppose that they tended to join up into the stable groups that we recognise as atoms, and these, in their turn, united to form the molecules, aggregates of which we call specimens of matter. Such a picture agrees with our faith in evolutionary doctrines, from which it gathers strength.

When, from inorganic matter, we turn our attention to the living organism, we find that Nature, with her accustomed economy, has made use of the materials at hand, and in new combinations produced fresh structures. The bodies of plants and animals are made of the same chemical elements as we find in non-living matter. Chemically, organic and inorganic matter are identical in this respect. They differ in that, in living things, only a few of the available elements are used, and with the few, much more complex structures have been built. The complexity lies in the number and intricacy of arrangement of the atoms which go to form the molecules of the organism. The basis of all living structures is the substance which we call protoplasm, a very complex material which in life, as we know it, requires about ten elements for its maintenance in the living state. Associated with the living protoplasm are other complex and equally essential compounds. Let us repeat, that, chemically, the living organism and the mineral differ only in the complexity of the molecules of which they are formed.

Is it not possible to conceive that the building up process, outlined above for inorganic matter, might be continued until, at some favourable time, the conditions were such as to produce a combination recognisable as protoplasm, possibly a simpler protoplasm than we now know? Few would care to deny such a possibility, yet if we grant it for the sake of argument, it still does not go far enough. If at some favourable time protoplasm did appear on the surface of the Earth derived from non-living matter, it does not necessarily follow that life was coincident with this appearance. We know much of the chemical constitution of living matter, and we can look forward with certainty to the time when the chemist will produce, in a test tube, a specimen indistinguishable from living matter, from a chemical point of view. *Will it be living protoplasm or just protoplasm? Will the vitalist or the mechanist be triumphant in that day?*

There is no answer other than the political tag, "Wait and see!" We can add, however, a little information as to the most probable conditions for the formation of protoplasm by the grouping of elementary substances. Living matter seems to be differentiated from dead matter, by the collection, storage and utilisation of energy that it undertakes. The lowliest forms of life that we now know, derive this energy, for the most part, from the heat of surrounding bodies. It is not until we reach higher forms of plant life that we find the energy of sunlight trapped and used. Also, we associate such lowly forms with life in water. Hence we postulate the first mainfestations of life in a primordial ocean, hidden from the rays of the sun by a dense covering of cloud, and warmed by the heat of the Earth. Such a set of conditions would be likely to follow the hot, arid conditions, described earlier in this chapter, and, in the mud of these primal oceans, we imagine the first living protoplasmic combinations to have arisen.

When or how protoplasm acquired the quality of insurgence that we call life, we do not know, and whether we shall ever know is doubtful. However, once it is added, the tiny specks of living matter would crawl in the primordial mud, they would develop lash-like extensions and swim in the waters above. With the lightening of the clouds, they would learn to trap the sunlight and "in the inshore waters, shallow enough to be well lighted, some of the primeval forms of life anchored themselves and grew out into long threads and broad plates—the first seaweeds. . . . But among these there emerged a new kind of life, minute predatory creatures that fed on the plants and their fragments. These were the first animals."

Speculative as these suggestions are, for we *know* nothing of the origin of life, they do unfold before us a possible plan, the magnificence of which is awe-inspiring. We justly marvel at a mighty city, when we envisage the few rough huts that marked its foundation, but that life, as we see it to-day, began as a tiny speck in dim past ages, that insistently it has striven towards the present, with all its variety of form and intricacy of culture, is a story of progress mightier than any city can tell. It is a heritage of rich tradition, pregnant with potentialities for the future, that, in the present, should be a never-failing call to Mankind, to strive to know and understand the Nature that first gave life to the world.

CHAPTER VII

INHERITANCE

" . . . you may take my word, that nine parts in ten of a man's sense or his nonsense, his successes and miscarriages in this world depend upon their motions and activity . . . so that when once they are set a-going, whether right or wrong, 'tis not a half-penny matter,—away they go cluttering like hey-go mad." TRISTRAM SHANDY.

WHEN dealing with such a fundamental subject as heredity, there is no place for doubt. Vital matters, concerning our everyday life and the future of the world, are at stake. Our social organisation rests on a sure foundation only so far as we understand and interpret the facts of heredity. We must draw a hard and fast line between the speculations of philosophy and the facts of observation. What we do know, and what we do not, must be made explicit, for in the practical affairs of life it is often safer to work in the dark, knowing it to be dark, than to mistake the half-light of theory for the mid-day glare of truth.

So, noting the inherent difficulties of the subject, we shall attempt to be dogmatic as to where fact ends and speculation begins—which is all the easier because there is little fact and much speculation.

Heredity and inheritance suffer, as a subject for scientific discussion, from the fact that we all possess ideas of inheritance based on the legal and social significance of the subject. Such an aspect implies the " handing on " from one generation to the next of a material possession, which has been accumulated by the individual. From a scientific point of view we shall find little in common with this idea. It is in only a very limited sense that we can speak of the handing on of anything material, and further, we have to distinguish carefully between the social inheritance, the contribution of the family, the nation and the age, and that which the individual owes to its immediate ancestors.

Let us briefly outline the position as we see it. As far as we know, every living thing takes its origin from some parental form. Some mode of reproduction is implied in the continuance of life on the Earth. The reproduction may be by some such simple process as budding, but as we ascend the scale of life, we find that the higher forms of animals and plants have adopted a mode of reproduction that we call sexual, and which concerns two individuals, or at least two components—male and female—from one individual. It is this type of reproduction and the inheritance concerned with it, that will engage our attention.

It is common knowledge that "like tends to beget like." We do not gather roses from a thistle, or breed horses from camels. Opposition to this belief has arisen, but so far the evidence adduced in support of the opposition has not survived critical examination. *Like tends to beget like*, but we must not forget that it is a *tendency*; for the offspring of any parents are not identical, they differ from one another and from the parents to a recognisable degree.

At this stage we must note that it is in the young that this likeness to the parent is most obvious. The sons of a typical country squire will resemble their parents very closely, while as children they play around the home. As they grow up into maturity, one may become a colonial with a happy-go-lucky outlook on life, and muscles of iron, another may become a narrow pedant, the third may prosper in business and develop the corporation necessary for municipal office. Changes in environment produce big external changes; yet all three may have children who would fit very well into the original country home.

This leads us to the consideration that heredity is not some subtle force, which of itself could produce an individual. Leaving out of consideration cases of reproduction that are not sexual, as being concerned with lowly or primitive forms of life, we may state that every organism commences life as a solitary unit, the product of the combination of two germ cells, derived respectively from a father and mother. That solitary cell is the entire inheritance. Given the necessary environment suited to its nature, it will develop into a fully grown individual, like unto its parents, by the process that we call growth. If the environment fail, then the embryonic cell will either die or develop into a freak. Once the organism is started, then it is the environment that makes possible the development of the potentialities that constitute the inheritance. *The individual is the product of its environment and its inheritance.*

Here, again, we tread the firm ground of agreement, but the moment we attempt to assess the relative value of environment and inheritance or to explain how they work, we step into the swamps of speculation. Let us approach this difficulty from a slightly different angle. Prior to the nineteenth century it was a simple matter. "Special creation" or "spontaneous generation" had peopled the earth with a variety of plants and animals, and the super-product, Man. Among these, like begat like, with minor and unimportant variations. A thistle was a thistle, and always had been a thistle. The coming of evolution, applied first to inanimate things and then to living matter, changed this view of life entirely. Scientists read a story of life in the fossils of past ages, they compared the structures of different species of animals and plants, and they conducted experiments on the variations of living things. From all angles came confirmation of the belief, that the variety of life had not, once and for all, been fixed at some distant "creation," to pass from thence down the ages in unchanging succession. It was seen that the simple preceded the complex, and variety was the result of diverging change. *Evolution became an established fact.*

Once the facts are known, evolution becomes so obvious, so convincing, so satisfactory that it adds very little to the answer that we seek. We accept it unquestioningly, and immediately ask how it works. Darwin and Wallace, who crowned all evolutionary thought with their enunciation of its principles, and the statement of detailed evidence in its favour, realised to the full that evolution could only be brought about on the raw material of the variations which we have noted. If the progeny of all parents, within a group, were identical then there would be no evolution.

Long before Darwin, this variation had been observed and made use of by the practical breeder and cultivator. Darwin and his school performed the useful function of sifting the chaff from the corn and scientifically examining the purified product. They recognised, as we all do, that the variations themselves may vary. In a human family, for example, the variations will be usually small, but occasionally a child will arrive, so remotely resembling the parents, as to provoke comment. Such also is the experience of those whose life is spent attending to the reproduction of successive generations of domesticated animals and plants. The Darwinian survey of the field led to the conclusion that the smaller variations were of greater importance. The larger ones were thought of as being rarities, and, when they were produced and survived, it was supposed that they would soon merge into the common stock by the process of cross-breeding. So Darwin modelled the ways of Nature on those of the breeder, who, selecting favourable variations from his stock, gradually builds up a strain peculiar in the possession of some characteristic which is strengthened from generation to generation.

From this point of view, evolution, the gradual alteration of species, was brought about by a process of selection. We need not go into any detail as to the various selective agencies proposed by this school. *Whatever they might be they would be part of the environment of the individual, and naturally such environment would tend to favour those variations most suited to fit it.* Evolution by selection means the survival of the fittest.

All that can be accepted as gospel, but since the days of Darwin the facts have materially increased in number. His work called the attention of naturalists to a vast field of research, in which many a famous man has since collected valuable data. Stated briefly, this further work has forced attention to the larger variations that occur less frequently than the minor ones. In the first place, it has been shown that, especially for plant life, they are not so rare as was supposed. For such variations De Vries proposed the name *mutations*. It was further shown that it did not necessarily follow that mutational forms would die out by inter-breeding. The variation might be transmitted from generation to generation.

The present position is, that we cannot ignore the possibility of a fresh species being started by a mutation, and there is an inclination to give to them a greater share in the production of the variety of life, than to the very slow changes that would be produced by selective agencies alone. Both the variations necessary for selective evolution and mutation arise, as far as we can see, fortuitously. Futurity is, from either point of view, a matter of blind chance, by no means a pleasing reflection and one to which we shall return shortly.

Under pure Darwinism the individual does not play a very great part. Minor blind variations are possible and the rest is left to environmental influences. Man's influence, if of any value at all, must be devoted to modifying the environment to his own ends. The mutational theory, on the other hand, exalts the individual, and attaches little importance to the environment. Inheritance becomes the all-important factor, but as mutations are fortuitous, at least as far as we are concerned, it leaves us in a still more hopeless position. Undoubtedly neither theory expresses the whole truth. It may be that both are true within certain limits; mutation may initiate organic novelties that selection improves and establishes—a statement to which fairly general agreement would be given.

However wide such general agreement would be there still remains ground for serious debate. Environmental influence on the growing individual has been observed from the earliest times. The blacksmith's brawny arm is the result of his hammer-and-forge environment. His father may have been a puny dweller in the city, and so this *modification* of the blacksmith's body is entirely his own achievement. Will his children inherit what he has acquired by *use*. Again, the son of an athletic family may forsake the playing fields for the seclusion of the study, and the physical perfection, inherited from his parents, be replaced by general weakness. Will his children inherit what he has lost by *disuse*? In general, will characters, acquired during the lifetime of the individual, be transmitted as an inheritance. For centuries the answer to this question was an unqualified "yes," for such seemed to be common experience. Even to-day, it is widely believed; the children of drunkards will be drunkards, criminals beget criminals we say, we inherit consumption from consumptive parents, and drunkenness, criminal tendencies and consumption we consider as things which can be acquired. The name of Lamarck, who, before Darwin's time, set forth this idea with such telling force, is associated with this school of thought.

Evolution by selection gives a decided negative answer. The possible variations are small and vary about a mean in both directions. The children of a criminal should be, some a little better, and some a little worse than the parent, and a wise social structure would eliminate the little worse and cultivate the little better. Mutations occur anyhow—a kind of jump in any direction—and so do not alter the Darwinian position. This position finds its best exposition in the theories initiated by Weismann. Life commences as a single cell, which by the process of growth forms two cells, and so the multiplication goes on till the organism is complete. All the daughter cells are not, however, alike; except in the lowliest forms of life in which the individual consists of one cell only. In higher, and many-celled, plants and animals a process of differentiation takes place. There is a division of labour whereby one group of cells become modified to undertake special duties, such as the formation of the skeleton, the flesh and blood that clothes it, the nerve cells, and so on. Once a cell is differentiated in this way, it almost invariably loses that potential power that is possessed by the original cell, of giving rise to all the kinds of cells that the organism needs. There is, however, in the development of the individual, always left a residue of germ cells, containing this potential power, and given suitable conditions, they will give rise to fresh organisms. In this way we distinguish between *body* *cells* and *germ cells*. The Weismann school consider the germ cell as a thing apart, for which the body is but a container.

Now, the modifications which we are considering—such as the blacksmith's brawny arm—are changes of body cells, which, according to this theory, have separated and ceased to affect the germ cells. The germ cells hold all the inheritance, and modifications of body cells can have no effect on this inheritance. According to this view, acquired characters cannot be transmitted. At first sight it seems a simple matter to settle such a dispute by direct experiment, even if such has not been done by human experience already. The consumptive mother has a consumptive child. The mother acquired the disease, for her ancestry is free of all taint of it. Here, it seems, is plain proof of the inheritance of an acquired character. Such is, however, but a superficial view of the case, for which there is not a shadow of positive evidence. We are dealing here with a case of infection, either before or after birth, which does not necessarily take place, and is therefore not inheritance. Analysis of cases, where such inheritance is claimed, always seem to be associated with some such difficulty, often much more complicated than the simple illustration given above. The difficulty is to be certain that we are dealing with an acquired character. A character, apparently acquired, might be the result of environmental effect on the germ of the parent. Again, what seems like inheritance may only be the repetition of parental modification by a repetition of similar environmental influences on the offspring.

The inheritance of acquired characters is certainly not proved to the satisfaction of the scientific world to-day. Still, we have to realise that the Lamarckian school at present is very wisely stressing the individuality of the organism. Darwinism is a scientific theory of chance, having its foundations in the speculations of ancient Greece. It leaves the individual helpless in the hands of mighty forces over which he has no control. Man prefers, however, to believe that, at least to a certain extent, he is master of his fate. There is a growing body of opinion that sees in the living organism something that is "self-adaptive, self-repairing, self-perfecting, self-regenerating, self-modifying, self-resourceful, self-experimental, self-creative." Life does not always go with the stream, at times it goes against it.

Whether we consider the germ of life to be a passive thing moulded solely by external stimuli, or whether we endow it with a potential plan of operations, in the nature of a drive forward in a definite direction, we see that inheritance must have a physical basis. There must be a process by which whatever is inherited is passed on. Towards a description of this physical basis large strides have been made recently. The primary cell from which the organism develops, grows by a process of cell division. Within this cell lies a structure called the *nucleus*, which contains "small particles strung, as it were, on a network of fine threads." When cell division takes place these particles "collect together in the form of a long coiled thread, and presently this thread breaks up into a number of longer or shorter pieces." These pieces are the chromosomes, and all the cells of one organism contain the same number of chromosomes. Subsequently the chromosomes split into two, forming two identical groups, which move away from each other and form two new nuclei, between which a fresh cell wall is made and thus two daughter cells are formed, which are identical, so far as their chromosome content is concerned.

"We look upon the chromosomes as the physical basis of heredity," containing within them "factors corresponding to definite qualities." These factors are "regarded as exceedingly minute, but definite bodies, having relative permanence, and the capacity for reproducing their like. . . . Probably there will come a time when we shall be able to apply direct chemical tests to determine whether this or that factor is present in an individual."

Here we have quoted modern exposition, red-hot from the laboratory. Possibly its cheery optimism is born of enthusiasm, but it is enthusiasm based on a very sure foundation. We are making rapid progress towards a complete description of the mechanism of inheritance, which surely will help towards a solution of the main problem, the problem of life and inheritance.

We are left wondering. If acquired characters are not hereditable, what is the use of education? If the basis of change is blind variation, either small or great, what is the use of social reform? If nature is a mathematical game of permutations and combinations of factors in the chromosomes, determined at birth, then, why struggle?

May we not seek inspiration in the realisation; that, so far, we have but dealt with a material heritage, a mere matter of cells. We are still left with that greater treasure the heritage of the arts and crafts of the mind of man, which in very truth are handed down from generation to generation, and ever grow deeper in tradition, and wider in content from age to age.

We will break the story of inheritance here in order to renew it in the next chapter from a somewhat different standpoint, and thus emphasise the fundamental connection between inheritance and evolution.

CHAPTER VIII

EVOLUTION

"Lo! mighty Mother, now be judge and say whether in all thy creatures more or less change doth not reign and bear the greatest sway."

SPENCER.

ALTHOUGH in the previous two chapters we have had occasion to refer to evolutionary doctrines, it will be advisable, in view of the very prominent position that recent events have given to this subject, and to the important position which it occupies in our whole outlook on life, to deal with the subject in a little more detail. After all, evolution is the basis of all our actions, for it has soaked through every domain of science into the fabric of social law and order. It has invaded even the sacred precincts of Religion, and tinges life from dawn to sunset.

Evolution was not the invention of the celebrated Darwin. Its history is age-long, and, as we all know, the actual contribution that Darwin made, was almost forestalled by Wallace, and had neither lived, others would have contributed the necessary impetus to thought. The flower of the tree of knowledge was due to burst into bloom at that time; but the fruit is not yet completely ripe.

The first evolutionist of importance that we need mention is Lamarck, who, believing in the direct influences of environment to a very marked degree, based a system of evolution on this. He imagined that, in response to new physical needs, new structures would be evolved; that by use and disuse these structures would grow or decay. Such modifications of the individual, he supposed would be inherited by the immediate progeny and thus new species would arise.

Following Lamarck came a period of conjecture, and the general idea of gradual transitional change grew in favour, not only in the fields of plant and animal life but in all branches of thought. The idea that the world was "as it was in the beginning, is now and ever shall be" became untenable.

Darwin studied the problem from a strictly scientific point of view. He reviewed the evidence for change that was available and devoted a lifetime to the extension of his knowledge. Within his purview he collected the facts of geographical distribution of species which his early travels had revealed to him. He considered the geological sequence of life as investigators in this field amassed instances of it. The growing science of embryology contributed yet other evidence, in the prenatal history of the young. The study of the structure of animals revealed a close approximation to a common plan. The arm of a man, the foreleg of a horse, the wing of a bird, seemed but structural modifications of one common skeleton. Further, he found a gradation of organisms from the simple to the complex. Everywhere was variation and diversity: occasionally the variations were large, a phenomenon on which, as we have seen, De Vries founded his mutation theory fifty years later. Darwin noted the struggle for existence, coupled with the enormous overproduction of plants and animals. Millions of young were produced that one might live.

Having carefully considered his facts, and verified his evidence, Darwin launched his theory. From the millions of young produced, only those most fitted to the environment would live. For each generation, the environment would select the best. But, no one of the new generation would exactly resemble its parents. Therefore those which survived, in virtue of minor differences that fitted them best for the struggle for existence, would form a new generation slightly removed from the old. The living would make the best of whatever their slight advantage was, and by continual use it would be emphasised. The next generation would contain a still larger proportion possessed of this characteristic, and so, slowly, generation by generation, the new would be evolved.

Darwin later introduced another selective agency—sexual selection—by which it was supposed that the female, at the time of mating, would select the male, among her competing suitors, that most pleased her, and thus perpetuate the particular characteristics which pleased and were possibly useful. This theory has not met with approval and we need not give it further consideration here. Darwin published all his work in the spirit of scientific caution, drawing only such conclusions as seemed justified by the evidence available. His work led to the establishment of the continuity of change, and set the seal of truth on the rather nebulous evolutionary doctrines then extant.

There was little real conflict between the views of Darwin and Lamarck. Darwin's work covered a wider field and rested on surer foundations. Both preached the importance of the environment, if from slightly different points of view. The theory met with instant support and survived a trying time of conflict with the theological powers. It was extended to the whole Universe and in popular circles found a ready acceptance, so reasonable were its tenets and so clever its exponents. Later workers enriched the evidence in its favour and a notable contribution was made by Weismann. Weismann drew a definite distinction between the cells that produced the body and those which produced the germs from which future generations arose.

The body, composed of somatic cells, became a mere temporary receptacle for the germ cells, inherited from the parent. The body was in no way able to influence these germ cells, and thus the possibility of acquired characters being inherited did not exist. The continuity of life lay in the continuous stream of germ plasm passing on from generation to generation. The germ plasm theory was accepted by the majority of students of the subject and the Lamarckian view fell into disrepute.

The position towards the end of the nineteenth century was that the theory of evolution in its broad aspects was generally accepted. Masses of evidence in its favour had accumulated and few doubted that life had been continuous from the beginning of things. The present century has seen that continuity challenged. As the chemist and the physicist have been compelled to give up the idea of the continuity of matter and recognise the atom and the electron as the units of their sciences, so the challengers claim that life moves by jumps, which at times might be very great. We need not elaborate what has already been said on this point in a previous chapter, but it is necessary to refer to the work of Mendel before we leave the subject. We cannot go into it in any great detail, but it has important bearing on the question of inheritance and evolution and is receiving much attention at the present time. Mendel, the philosophical Abbot of a quiet monastery, turned his attention to the subject of inheritance from a fresh view-point. In all that preceded him, and for fifty years after his work, all problems of inheritance had been tackled from the standpoint of the individual as a whole. The son, admittedly not a "carbon copy" of the parent, as Dr Crew so vividly phrases it, was yet on the average very much like the parent. The red-haired offspring of dark parents still possessed so many of the family characteristics as to make the idea that like tends to beget like, applicable in its widest sense. Mendel in a series of masterly experiments covering a period of eight years, ignored the individual and confined his attention to smaller characters of inheritance.

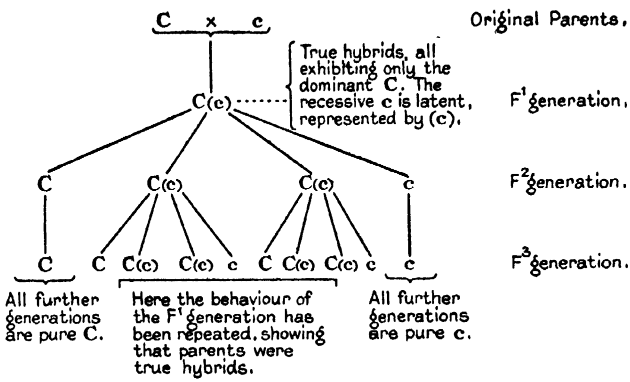
He was fortunate in his choice of material for experiment, selecting after careful consideration varieties of the pea tribe of plants, the common edible pea. All the varieties, with which Mendel experimented, were undoubtedly members of one species and recognisable as such. They differed in minor points. For example, one variety possessed a ripe seed that was round and smooth, another variety had wrinkled seeds ; some were green in colour, some were yellow. Mendel concentrated on these small differences. He took two plants possessing opposite characteristics and produced from them, by artificial fertilisation, a hybrid. The hybrid plants were then propagated by self-fertilisation, no further crossing taking place, and the process continued for several generations. Each generation was very carefully examined for the characters of the parents, and results very surprising at that time were obtained.

It was found that the original hybrids all resembled one or the other of the parents : never both. Intermediate forms were not produced. Thus a round-seed variety crossed with a wrinkled-seeded one gave rise to a hybrid generation all of which were round-seed varieties. It did not matter which of the parents was the round-seed one, this characteristic came out on top every time. Round-seededness in this species of pea was called a *dominant character*, the wrinkled character being called *recessive*. Any pair of characters which behaved in this way were known as *allelomorphs*. This hybrid generation is called the first *filial generation*, and is referred to as the " F^1 generation " for short. At first sight it seems as if the recessive character has been lost, but in the next or " F^2 generation," obtained from the self-fertilised hybrid, it reappears. On the average of a large number of examples, the F^2 generation consists of three round-seeded individuals to every one wrinkled example. The character that was " lost " in the F^1 generation appears once more in the F^2 generation.

Still more remarkable are the results which are obtained in subsequent generations. The wrinkled varieties, which appeared in the F^2 generation, breed true. All their progeny have wrinkled seeds, however many generations we follow them through. In the remaining members of the F^2 generation we find that one-third of them breed true, giving round-seeded varieties only, while the rest split up in the next generation into the three to one ratio observed before. In these cases there is a sorting out or *segregating* process as we go from one generation to the next. This segregation is best seen if we represent it diagrammatically. We will let the capital letter " C " represent one of the characters of an allelomorphic pair, and the small letter " c " the other. The " C " character we will suppose is the dominant one. Then if we mate two individuals possessing respectively the " C " and " c " characters, their progeny will be represented ideally by the scheme on facing page.

It must be pointed out that such an ideal scheme is only obtained, when the average of a large number of individuals is considered. Irresistibly we are led to the conclusion that the inheritance that we are studying is a process of handing on of *unit characters*. In the hybrid generation the recessive character is in some way kept in a passive state, to appear later in one quarter of the progeny of the hybrid. The example that we have chosen is a very simple one in which the results appear very clearly. When we combine two or more unit characters that are allelomorphic, the results become somewhat complex, but lead to a similar conclusion when analysed.

Mendel carried out thousands of experiments before



publishing his work in an obscure technical journal, and in the bright light of the contemporary theory of evolution, which seemed to make the whole problem so simple, it received practically no attention. It needed the preliminary work of Bateson to pave the way for such views as these ; and one of the notable achievements of recent biological progress has been the resurrection of Mendel's work, which was achieved by De Vries and other workers at the beginning of this century.

Mendel's experiments have been repeated on a much larger scale and confirmed in every aspect. They have also been extended to a far wider field and found to hold true for many characteristics of both plant and animal life. It is difficult at times to recognise the Mendelian ratio in breeding experiments because it is difficult to fix upon what exactly are the unit characters, which it has been suggested may be identical with the "factors" in the chromosomes which we have mentioned in the previous chapter. In man the difficulty is still greater, as centuries of cross-breeding has produced a very complex product, but that certain characteristics are inherited by man on the Mendelian plan is undoubted. At the present time not very great importance is attached to the idea of dominance, but it is recognised that where Mendelian inheritance can be shown to exist, it is characterised by the "orderly reappearance of the characters of the parent of the hybrid and the hybrid itself, in the second hybrid generation in definite numerical proportions." Its most enthusiastic adherents look for great extensions of the application of this method of inheritance with the continuance of the inquiry into masses of evidence that are accumulating.

It is necessary to note before we leave this subject, that it has been violently attacked in certain quarters. Many, who have devoted a lifetime to the study of a particular species of plant or animal, have been unable to recognise anything approaching unit characters or the segregation of the Mendelian plan. There is no question of the reliability of Mendel's experiments or of those of later workers. Neither is the conclusion drawn from this work challenged. The opposition appears to doubt it as the sole method of inheritance. Its applicability may not be so wide as has been imagined, and some if not many of the cases of blended inheritance may not yield on further analysis any support to Mendelian views.

The idea of biological units is by no means a new one. Darwin himself suggested a theory of inheritance in which "gemmules," originating in the cells of the body, congregated in the germ cells. Spencer introduced the idea of "physiological units." "The philosophical necessity which Darwin himself felt . . . has been followed by a long historical chain of representative particles, such as the *ids* and *biophers* of Weismann, down to the modern gene (or factor in the chromosome) which has been stripped of some of its mystery but is still essential for an explanation of the phenomena of heredity and variation."

As we think over and consider the modern position as regards evolution we see that it rests on a firmer basis than ever it did. Whether we accept the view that changes have come by jumps or by continuous movements is of little matter. After all, these are but attempts at explaining the mechanism of what is happening. It is very likely that both views are to a certain extent true, for life has a meaning that is wider than any mechanics. It may be that we are attempting the impossible in this minute analysis and that, as it has been suggested, *life* and *mind* are not reducible to simpler terms. Possibly they are the axioms of biology, and for ever will remain so. Nevertheless our explanations will still be philosophical necessities, and of use for our guidance, in that they serve to crystallise our thoughts and actions.

While dealing with the Theory of Evolution it is advisable to touch shortly on the question of its religious aspect. The long-forgotten squabble between religion and science has been recently revived, with this theory as the chosen field of battle. It is difficult to believe that this very much advertised campaign is genuine, and not the outward and visible sign of a sinister attempt to impose a doubtful authority on the world.

No useful purpose, however, is served by rhetorical abuse, and the only answer that science has to offer to the attack is the presentation of a vast array of facts which can be examined in the fierce light of reason. Science has nothing to hide. The work of the past seventy years on this theory is smudged by but one blot—the regrettable but much discussed false presentation of evidence by Haeckel. His other contributions wellnigh atone for his falling from grace; and there are few world-wide movements that can show a cleaner record. Although we believe that the theory is indeed fact, proven beyond cavil, there is no living scientist who would not willingly accept another and better theory if such can be found.

Let it be repeated, that science has nothing to hide. Frankly it is opposed to any religion that attempts to replace the freedom of individual thought for doubtful authority. Every individual stands alone in the cosmos, in a certain sense. We come into this world alone and we leave it alone; and while we are here we have the right to our own thoughts. Science teaches that we shall only make the best of that earthly life by so adjusting our actions as to be in harmony with Nature. No scientist of repute dare deny the philosophy that postulates a Divine Being and a divine plan of creation. He may claim the right to remain personally outside any particular philosophy; but it is not in the ranks of science that the atheist is found. One must go to the ignorant and the cocksure for this peculiar type of mind.

Science claims to be turning the sacred pages of the book of life as reverently as ever did the Saints of old. It hopes to give them a deeper and wider meaning than has hitherto been possible, and thereby make that much desired harmony possible for one and all. Only wilful stupidity or criminal malignity can place Religion and Science in opposition. Let us go back to that stern old puritan, Milton—

> "To ask or search I blame thee not; for heav'n
> Is the book of God before thee put
> Wherein to read his wondrous works and learn
> His seasons, hours, or days or months or years."

CHAPTER IX

THE TREE OF LIFE

"... *godlike for great brows Thou art, and thewed as gods are.*"
SWINBURNE.

THE origin of life is a fascinating speculation, which if ever we attain to full knowledge on the matter, may give us a new and powerful instrument to use in the progress of humanity. Heredity is a pressing problem towards the solution of which we have made large contributions, but for immediate interest its application to the evolution of Man is pre-eminent. Here, at once, we feel that we are dealing with those things which really do matter, although a truer view would be that we are dealing with the logical outcome of the more strictly scientific work. The present century has added much to our knowledge of the history of man, considered as a scientific problem, much that should be invaluable for future progress.

The problem of the origin and development of Man seemed at one time to be such a simple matter. The theory of evolution appeared to make it just a matter of a short time before all would be known. Fossil remains existed which showed a more primitive type of man, further research would reveal still more primitive forms, until at last would be found that "missing link" that would connect Man with the apes—and there the matter would be ended. The discoveries of ancient remains of man were made in due course, as methods of excavation were improved and wider fields were explored, but in place of the simple story there arose a mass of conflicting evidence and a story of great complexity. At the outset we may state that the gradual evolution of Man from some more primitive ancestor is established beyond doubt. This complete descent from the main stock of animal life may some day be represented by fossil remains but at present there are gaps in the chain.

Modern research has complicated the problem in this way. Starting from some primordial form of life, simple in the extreme, we suppose that gradual development took place. The simple strove to meet changing conditions, to make the most of itself, and so evolved into the more complex. Progressive life, with a common origin, began to branch. In one direction creatures developed in one way, possibly to suit a particular environment, possibly as the result of many factors of which we know little or nothing, among which we cannot neglect that insurgent quality of life which as often leads it against the stream as with it. The sum total was to divide life into various branches, each different, yet each retaining sufficient to show the common origin. Our study of the complicated result of our own day is made by an investigation of fossil remains. These are studied from every possible point of view, compared with other forms showing any relationship, fitted into the environment in which they are found, placed side by side with modern specimens akin to them. Thus, piece by piece, the pages of the history-book of life are being built up; but still whole pages are missing and many are but fragments. In this book we learn of great tribes of animals that have flourished and died out with the coming of new conditions to which they could not adapt themselves. Others, like the fishes, have persisted, with but minor modifications, almost as far back as we can trace.

In this story two points stand out in vivid contrast. In the first place we cannot help the realisation that specialisation spells death. We live in a world of continual change, to which life must adapt itself, or die out. The monstrous reptiles which in a former age predominated the animal life of the world, were the highly specialised product of long ages of evolution. Their terrible, nightmare forms were admirably suited for the kind of life they led, a suitability gained by ever-increasing specialisation to fit the conditions. In this evolution they lost their plasticity, they became incapable of modification other than along the lines they had adopted, and subsequent ages saw their total extinction. Again and again has such extinction occurred. We can see that a similar state of affairs exists at the present time. The predominant animal alive to-day is certainly the insect, which outnumbers all other animals many times over. This creature is most efficient in its life. Its body and its mind are adapted in a wonderful way to perform most complicated actions calculated to promote its own welfare and ensure the safety of the future generations. The efficiency, however, has been attained at the expense of special modifications of bodily form and mental attributes. Whole classes of insects are dependent upon the products of special plants for their life. They can construct their nests only under certain very precise conditions, and we can see that they would die out as the result of comparatively small changes in the general environment of the world. In fact, by very simple expedients man is able to eliminate injurious insects from any area.

Side by side with this specialisation we realise that somewhere in each age there remains the central stock of life tentatively pressing forward, and yet retaining that degree of plasticity which makes continuance from age to age possible. We might almost call it the conservative element of life and recognise that the race does not always go to the swiftest. Some creatures seem to rush to meet environment, and rapidly evolve special modifications to make the most of what is presented. Invariably the hustlers get left behind in the long run, and those more careful creatures who move slowly but surely are left to perpetuate life on the globe. To-day we are inclined to consider that Man is the representative of this central stock, for his bodily and mental structure is certainly less specialised than in any other animal. Man is able to meet changing conditions more easily than the beasts of the field.

We can apply this differentiation by specialisation not only to the whole animal creation, but to smaller sections of it. We should expect, therefore, in the history of man to find that a similar differentiation has taken place. Granting a common ancestor for all men, then the most probable course of development would be the gradual advancement of the main and most plastic stock, with here and there side branches suited to special times and places, and doomed to ultimate extinction due to specialisation. In our researches into the remains of ancient man we can expect to find evidences of these side branches, and our difficulty will be to distinguish them from the main stem, and to decide their point of emergence at some far distant time. As a matter of fact, we have very little on which to base our conclusions; a few scattered bones, crude instruments of stone and bone and other vague evidences of animal existence. The painstaking work that has been given to these stray pages of pre-history is worthy of every praise. No effort has been spared to sift the evidence through the finest sieves of reason, and although we have not yet reached agreement on all points of detail, the progress made is remarkable. We will attempt a brief summary of the main achievements.

First let us look at the actual discoveries of fossil remains of man, and consider them in the order of time which is revealed by the deposits in which they are found. Such order, of course, does not necessarily imply any relationship—Cromwell followed Charles I., and five thousand years hence historians will probably be disputing as to whether they were father and son.

The earliest known human remains consist of the roof of the skull, two teeth and a thigh bone found in a river deposit in Java. The science of anatomy makes it possible from such fragmentary remains to reconstruct a picture of the entire animal. Such reconstructions are not supposed to be true in every detail, but they are sufficiently accurate to enable us to get a very good idea of the creature with which we are dealing. The Java Man was a "being human in structure, human in gait, human in all his parts, save his brain." There is little doubt that he must be considered a member of the human family. These remains were found in deposits that the geologist calls Pleistocene. It is a pity perhaps that the geologist has chosen such awful names to date his chart of the world's history, but so doubtful are we as to the age in years of any geological period that to date them by our usual methods is only to rouse controversial passions.

Next in order of time we come to the remarkable remains found at Piltdown in Sussex. Here, again, the find was only of fragments but enough was obtained to give a fair idea of the nature of the skull. From the skull of an animal it is possible to judge very accurately its nature, and in this case the indications were that the Piltdown Man was "a real human being, but one in which there can still be detected gross traces of man's simian ancestry."

In the Broken Hill Mine in Rhodesia other fragments were found, for which it has been claimed that they represent the ancestral type of modern man, but the evidence in this case is less secure as to the true position in time. We have also the very recent discovery at Taungs, for which again very high-sounding claims have been made. Here, however, there seems to be much doubt, but as the specimen is still under examination by the specialists it is better to keep an open mind on the subject.

Later we have the fragment of a jaw found in the sand-pits at Mauer near Heidelberg. Here we have evidence of time that no one doubts, and the reconstructed animal is admittedly human, although " more bestial in structure beyond all kinds of men now living." The Galley Hill Man claims our attention next in point of time. This remarkable find is a fruitful source of disagreement. On the one hand, the evidence of age can only be disputed on the grounds that the Galley Hill Man is so close in structure to modern man that it is unlikely that such a form could have existed so far back in time. On the other hand, if we are to accept the evidence as it stands, we must modify our ideas of the antiquity of modern man considerably. It may be as well to point out the difficulty that arises in all these cases. The geologist by a careful study of the rocks has arranged them in a definite order of formation. Of this order there is no doubt at all, and any deposit that may be found can be dated with certainty against this geological record. If now in any deposit we find remains of animals, then either the remains must have been deposited at the time the deposit was formed itself, or they have been put there at some subsequent period. As I write I can see a small child burying a tin in the side of a sandy cliff. The tin is now side by side with material millions of years old, but if, later, someone digs up the tin, it would be a false conclusion to decide that it was also millions of years old because it was found *associated* with a deposit of sand undoubtedly of that age. The expert excavator would detect the signs of disturbance due to the original burial, but so often these finds are made by persons who have no claim to expertness, and when the specialist arrives either the evidences he seeks have been destroyed, or no one has noticed the little points that would make certainty possible.

The next type of man that calls for notice is the Neanderthal Man, the remains of which indicate "a loose limbed fellow with easy shuffling gait (who) in size of brain was not a low form . . . he had fire at his command, he buried his dead, he had a distinctive and highly-evolved form of culture . . . in most of the points in which he departs from modern man he approaches the anthropoids . . . but not all of them; he had his own peculiar adaptations." Here we have a distinctly human animal, supposed by some to be the descendant of the earlier Heidelberg man.

So far we have been dealing with very primitive men, dating far back into the Pleistocene period, probably covering from the beginning of this period to the early ice ages that spread over the northern continents later. If we except the Galley Hill Man, we are probably correct if we look upon these types as side branches from the main stem, which was slowly advancing to better things. Doubtless the future will reveal a richer harvest of remains from which we can fill in the details of these pages of history. The dawning intelligence of the human being, however, seems to have saved him from the disasters which entombed thousands of the lower animals and left their remains for our work. From what we do know, however, we can conclude that early in Pleistocene times Man as a distinct species of animal was in existence. This would take the beginnings of the human family back to the previous period in geological time known as the Pliocene, and indeed there is some shade of evidence for taking the beginning back still earlier, and dating it in Miocene times.

As we pursue the story upward in the record we see that the Neanderthal Man perished, he failed in the struggle for existence, probably going under to the insistent onward march of those other men, the main stem, who swept forward in time and left the Neanderthal culture a thing of the past. We can trace, by many evidences, the progress of these newer men as they spread over the habitable portions of the Earth, but the inter-relations of one group with another are very complex. Established groups disappear and others are found in their place, and new elements of culture have been brought; use has been made of the best of the old and the fusion has contributed to an ever higher stage of civilisation. This period is marked particularly by the works of man's hand. We can trace the gradual evolution of the use of what first came to hand, through the crude shapings of the earliest stages, to the elaborate carving of bone and stone of the New Stone Age. As we can associate certain forms of art with definite historic ages, so we can classify the work of these early men by the type of instrument that they made. Up to the time of Neanderthal man we find somewhat crude flint implements as the main product of manufacture, but even here distinct types have been recognised. These men probably lived along the banks of rivers, for most of their remains are found in River Drift and gravels. The rest of the Old Stone Age was spent in a climate recovering from the effects of glaciation and a period of cave life intervened, during which considerable progress was made in the manufacture of tools. In a wide view of this period we get a picture of successive ages when various races of men, each with its own particular culture, roamed the world. Their encounters sometimes led to the destruction of one party or again to the fusion of the two, but either way there was complication of the story. We have to disentangle relationship from succession; and it is succession only that is told by the meagre records we have found.

Of the first animal to be characteristically Man we know nothing. Long ages at least before he arrived, the monkeys and apes had broken away from the central stem and proceeded along their own lines of specialisation. The Java Man comes at a much later stage, and even then most likely off the main stem. Through the Old Stone Age, with all its changes of climate from ice to tropical conditions, the development continued slowly with side branches here and there. As the more temperate climate is reached we see the Crô-Magnon race displacing the Neanderthal men, at least in Europe, and age after age of separate cultures following, until we reach the New Stone Age. The more we know of this age the more civilised it seems. With the spread of Man the story becomes more and more complicated, but a rough approximation to what happened is as follows. A side branch broke away from these New Stone Age races, and developed into the Australian aborigine of to-day—a branch doomed to speedy extinction. Then another branch broke off to form the Mongol Races. With progressive lightening of the skin, we get first the type that we call the Alpine Races, then the Mediterranean type of man, and the stem terminates in our own type, the Nordic Races. It would be difficult to get general agreement to the details of this suggested scheme, but we may safely accept it in its broad meaning and leave the details to further discoveries and research.

At least it will be admitted that the Nordic Races are the most plastic of all the human races now living, and that the future lies before them and not any other races of mankind. There may be temporary set-backs to their progress, but in the long run they will win through by their ability to adapt themselves to changing conditions. Such a scheme as we have outlined here gives us a magnificent picture of Man's progress through the ages, a picture that gives to the poetry of Genesis a living fire, "For in reality the garden of Eden was world-wide. Even England was part of it. . . . So were the continents, Europe and the ancient lands of Egypt and Mesopotamia. Our search reveals that it extended to the most distant lands of Africa, Australia, Asia and America. Nor was the drama of the Garden enacted in a single morning; it has been going on for a million years and is still unfinished. There have been many scenes and we can see no sign of the curtain being rung down on the last of them. The drama of man's evolution was not staged on a favoured meadow for a single performance; it is still proceeding in our slums, country cottages and palaces, just as it did in the days when man's only roof was the wide dome of the sky."

We may doubt the story either entirely or as to its details, but we cannot but admit that it is a story worthy of Man, the wise. It is no mean tale that science has to tell, but it is perfectly legitimate to inquire in what respects it can contribute to the solution of the problems of the world. The scientific investigator is far too deeply immersed in his work to give time to utilitarian considerations. He may be conceded a life on a higher plane than those who make his work possible by the provision of the necessary funds for its prosecution. Yet all knowledge has a use, although at times we fail to find the correct point of application. In our own days we are facing problems that man has faced again and again. The conditions are different, but it is idle in the light of history to claim that Man is the "conqueror of nature," or that he rules the mighty processes which she initiates. Man may modify, he may substitute one influence for another, but for all that he is a part of nature, and all that he does is natural in this sense. It is only in harmony with nature that true progress can be made, and therefore it is to the scientist that we must look for that understanding of nature which will ensure the harmony.

The story of Man as told by scientific research has many lessons for us. We see that the human family has given rise from time to time to branches that have died out in the struggle for existence. We have attributed that doom to the evils of specialisation. Neanderthal Man was more specialised than you or I, and we can be certain that he did not seek his own extinction. He was probably even more efficient than we are, in the sense that he was sufficient for the needs of his environment. We are clumsy helpless creatures compared with other animals. Even a baby chicken a few minutes old can feed itself, while most of the adult population of England would die if left in the world to forage for themselves. Efficiency of mind does not provide us with very much help, for we have but to watch an ant's community, to realise that the mental efficiency there is far and away beyond that of our own towns and states. Our brainiest politicians and statesmen are baffled by the social and international problems of the age, but the ant mind is not troubled in this way, and the members of the ant community are so directed as to ensure their ready compliance—or as an alternative, death—to the rigid efficiency of the community. If efficiency is not the characteristic that makes for progress, to what quality of life can we look for guidance? The story of Man as told in the rocks and fossils provides us with the answer. Dominance has always come to that group which provided plastic material for the changes that necessarily must be made. It can be claimed for those races of mankind, which we recognise as the highest, that they exhibit physically and mentally more of the primitive than other less civilised races. The bushman has specialised for a narrow life under one set of conditions, the Nordic type can be found flourishing "from Greenland's icy mountains to India's coral strand." The bushman is fitted for the life of a nomadic hunter; under conditions of civilisation he pines and dies. The white-skinned nomad is equally at home hunting the lion in tropical Africa and the elusive ice in the crowded ballroom. He can drive a car as well as a horse, and his bodily plasticity is duplicated in his mental outlook.

In the story of mankind the specialist has died out—inevitably. Can we refuse to recognise this lesson. Our code of humanitarianism demands our sympathy for the lesser nations. We vainly try to educate the heathen on the principle that all men are equal. This very modern doctrine has implications of great danger to modern civilisation. It is not that in the long run the more plastic will fail. The endeavour, however, to run contrary to the teachings of Nature, to improve upon them, as it were, can but delay that progress for which we all sigh. There is no equality in Nature and there does not seem to be any going back. Once the choice of a direction of development has been made the animal seems to go steadily in that direction, and if a wrong choice has been made then the result is utter failure and extinction in the end. "A race once started on a certain course will persist in that course, no matter how conditions may change, no matter how hurtful to the individual its own changes may be, progressive or retrogressive, uphill or downhill, straight as a Roman road, it will go on to that appointed end"; or in the language of the poet we may say:

> "Oft, as he jogs along the Winding Way,
> Occasion comes to Every Man to say
> 'This Road?—or That?' and as he chooses then
> So shall his journey end in Night or Day."

Such conclusions, based on a study of the past, call for serious consideration. It is better even to call a halt, than to proceed along the wrong path. Possibly, however, there is no halting in life. Progress must then, when there is doubt, be tentative only, with scouts on either side, lest we miss the true path. Hasty social legislation is an act of folly from which there is no relief. Even if, at present, there is much doubt as to our proper direction, the story of Man does provide broad generalisations for our guidance, which are founded on sound evidence.

As a race we must fight against any alliance with other races not on the same track as ourselves. We must contend vigorously against any attempt to stamp us into some common mould, possibly more fitted for present needs, but attained at the expense of plasticity. The ant-hill is no model for our community, and if the politician knew a little more of the life of the ant, he would leave its lessons out of his preaching. Freedom, in its widest sense, must be the slogan of the future, freedom for the community, as a whole, and freedom for the individual within it.

For the individual there is also a lesson, for do not the individuals make up the whole community. That does not imply that the whole is simply the sum of the individuals. Plasticity in the individual is typified by the open mind; which is not a mind that will accept anything, but one which retains the power of critical examination of any facts presented to it. The preconceived idea must not be allowed to rule our lives. We must be ready to adopt new ideas and adapt our actions to their implications. We have the bodily and mental structure at present that will ensure our future success, and it is our task to see that this valuable heritage is not squandered.

Explanatory Note on Chronology.

The geologist studies the crust of the earth, with a view to tracing the history of the rocks of which it is composed. These are now arranged in chronological order and fall naturally into groups, that serve to date the story. It is impossible to give any reasonable figures in years for these dates. Such efforts have been made but have never met with any general approval. In the table on the following page an attempt is made to illustrate this geological record, with special reference to the history of man.

Geological Periods.	*Human Cultures.*	*Probable Date.*	*Human Remains.*
Quaternary	Steel		
	Iron		
	Bronze		Modern Men
	New Stone Age	2,000–8,000 B.C.	
	Old Stone Age: Azilian	8,000–10,000	
	Magdalenian	10,000–13,000	
	Solutrean	13,000–15,000	
	Aurignacian	15,000–20,000	Crô-Magnon Men
	Mousterian	20,000–40,000	Neanderthal Man
	Acheulean		Galley Hill Man ?
	Chellean		Heidelberg Man
	Strepyan		Piltdown Man
Tertiary: Pliocene			Java Man
Miocene			? Human Family began
Oligocene			
Eocene			
Secondary			
Primary			
Pre-Cambrian			

The whole table has a relative rather than an absolute value.

CHAPTER X

A MEDDLER

> "*Then rose a different land . . .*
> *Ministrant there to health and public good,*
> *The busy axe was heard on every side,*
> *Opening new channels . . .*" SOUTHEY.

MAN, the wise, stands to-day before the world as the conqueror of Nature. It is a moot point as to whether there is much in the conquest. Possibly a truer view is that which sees Man as the animal which understands Nature best, and has used the understanding to bring his life into accord with her main tendencies. Still, through the long ages of his evolution from a primitive ancestor, Man has striven to command or understand the mysteries of his environment. Not content with mere adaptation of his own frame and mind, he has challenged the changes which occurred around him and moulded them to his own advantage.

Early in his history Man snatched the burning brand from the fire and raced with the " red flower " through the primal forest to his cave dwelling, where anxiously he tended it and fed its insatiable craving. His responsibility became his reward in the increased control it gave him over the vagaries of climate. With fire as his ally he could defy the rigours of winter, with fire he learned to cook his food and opened possibilities of ever-widening fascination. The discovery of fire-sticks for the generation of the warmth-giving flame, doubtless accidental, served to extend this control, which in our own day has developed to such an extent, that we may define civilisation as resting on a foundation of fire—in the home, the factory and the engine.

At some time in those early days the rocks were mastered also, and chipped and shaped for various purposes. Thus in his tools Man provided himself with extra limbs for special purposes without that specialisation of bodily form that ultimately spells stagnation. His "extra limbs" grew in number and in intricacy until in our own times they carry Man through the water and the air and over the land. They stretch out and kill the prey miles and miles away; they minister to his comfort; protect him from adversaries and lighten his darkness. To look at it from another point of view. These contrivances, which Man has made, give him the strength of the lion, the swiftness of the deer, the range of a bird, and the eyes of a cat —and leave his own organs free to develop in new and unexpected ways.

The mind of one man turned misfortune to useful account when, stepping on a tree trunk, he rolled in the mud, yet stayed to invent the first primitive wheel. Another found the uses of a lever when blindly attacking a task beyond his strength; and the wheel and the lever became the basis of a science that to-day has given us the locomotive and the aeroplane. The conjunction of fire and rock gave the first manufactured metal to the world; and Man seized the opportunity and an age of steel ensued in due course. Indeed, wherever we look we find this gradual conquest or understanding of inanimate things, a conquest which is by no means finished. The future viewed from the present seems to open possibilities of vast magnitude in this respect. Our leading scientists tell us that we are only just beginning to understand the structure of the universe. The primary need of every animal is energy, and Man has mastered every form of known energy with one exception—the energy evolved in radio-active change. We hardly doubt but that the future will see our conquest of this, and when that is accomplished we shall control sources of energy that will make our present supplies seem like mere playthings.

As we progress we bring the aid of intellect and reason to bear with ever-increasing effect on our actions, and it is a point for discussion whether we are in all cases making the best use of these regulators. Much that we do seems at times to be carried out in the dark as to the ultimate end. Our difficulty is that none of us are very sure exactly where we are going. We see what promises to be a very profitable field of conquest, and every energy is directed to its immediate conquest. A remarkable illustration of this is afforded by the past century of railway activity. "Locomotion No. 1" opened a road along which humanity streamed with feverish activity. The iron shackles were rapidly bound on the surface of the earth. Vast schemes were devised and carried out, and vaster ones still were to follow. Twenty-five years ago it seemed as if it was but a matter of time for the whole Earth to be almost covered with railway tracks, yet in the twenty-five years the whole business has come to a practical standstill; and it seems very unlikely that there will be any further great extensions of railway construction.

Our thoughts are now turned to transit by air, a method of progress that bids fair to put the express train alongside the stage-coach in a museum of antiquities. This intermittent aspect of Man's effect on Nature stands out very strikingly as we survey the past. In all great movements there have been periods of immense activity followed by stagnation, and even in some cases by entire reversal. It is almost as if humanity were still in its childhood, and the "new toy" is the centre of attraction till something else comes along, and the old plaything goes on the scrap-heap. However comparatively short each effort may be, we can still recognise that the sum total is vast. So vast, in fact, as to engage the earnest attention of our best thinkers, with a view to ensuring that future efforts may be better directed, and free from the frequent ills that have followed in the train of rash endeavour in the past. Let us consider a few concrete cases in order to illustrate the directions in which Man has "interfered" with Nature, and the importance of the work that he does.

It is difficult to classify the various activities which we recognise as having a definite effect on natural conditions, for they overlap to such a great extent. We may chose as our first illustration the work of Man as a geological agent. Geology deals with the changes that occur in the crust of the Earth, and here at once we realise that man has played no small part in the production of these changes. He has, for example, dug and burrowed into the ground from time immemorial; first, for the construction of shelters, and then for the treasures that lay beneath his feet. It is difficult to assess the extent of this work of excavation, and any figures dealing with it must be carefully scrutinised to find their true meaning. Certainly what we do know is surprising enough. The construction of the railways of the British Empire alone has necessitated the excavation of some 40,000,000,000 cubic yards of material. If this were heaped up over the Administrative County of London, which covers about 117 square miles, it would form a mound over three hundred feet thick. Railways, however, are not the only excavations that Man has undertaken. Dr Sherlock has recently completed an estimate for the total excavations in Great Britain from the earliest times up to the present day. His figures are the most reliable that can be obtained, and although they do not pretend to a very great accuracy, they do give a reasonable approximation. The figures he gives are as follows:

Total excavation in Great Britain.

	Cubic Yards.
Mines	19,692,000,000
Quarries and pits	15,500,000,000
Railways	3,030,450,000
Manchester Ship Canal	53,500,000
Other canals	200,000,000
Road cuttings	624,000,000
Docks and harbours	100,000,000
Foundations of buildings and street excavations	500,000,000
Total (about)	39,700,000,000

Such numbers as these have very little meaning, and it will help to a realisation of their immensity if we state that this amount of material, spread over England and Wales, would form a layer about eight inches deep.

This list by no means completes the toll of denudation by human agency. The wear and tear on our roads is estimated to amount to four hundred cubic feet per mile of road in every year, which means an average annual replacement by some seventy millions of cubic yards of stone in Great Britain alone. Mining operations nearly always lead to subsidence in the neighbourhood of the mines, and in some cases this may take place on a very large scale, making noticeable differences to the country. Between 1901 and 1911 a lake was formed near Walsall, due to subsidence, with an area of 97,750 square yards.

On the other hand, Man's action on the crust of the Earth does not always result in wearing it away.

Immense masses of material are added by human agency to the surface. In the past four hundred years some forty-three thousand tons of coal ashes have been dumped somewhere on our island home. Buildings of brick, with a combined volume of nearly seven hundred millions of cubic yards, existed at the time of the census in 1911. Forty-five thousand tons of broken glass appear every year in our dustbins. If the colliery tips of our coalfields were collected together, they would form a column one thousand three hundred and fifty feet high on a base of ten square miles. Then, Man has contested with the ravaging waves of the Sea for valuable land. In the Tees estuary alone waste slag has been tipped to such an extent as to reclaim some four thousand two hundred and seventy acres of land. Drainage of the Fens has given us one thousand three hundred and six square miles more land on which to raise valuable crops of grain. In twenty years over a million tons of solid material were dredged from the Trent and Mersey Canal, and about eighteen and a half million tons of material were taken from the Tees up to 1885 and dumped somewhere.

We might extend our observations and give masses of startling figures almost without limit, but enough has been provided to indicate the scale on which human operations are taking place. Dr Sherlock's final conclusion is that Man's effect on the land surface of the British Isles is that it would remove a layer of five and a half inches in a period of two thousand years, if his efforts were averaged out and the present rate maintained. This estimate is about double the rate of wearing away that the geologist has assigned to the natural forces of denudation. We have recently seen the whole nation concerned for the safety of St Paul's Cathedral, imperilled by the subterranean activity in

London, but the problem has a wider significance than the preservation of this historic building, for we can see that there is a direct relationship between the problem and population. Most of this alteration to the land surface has occurred since the industrial revolution peopled the world with teeming millions. As there seems every prospect of this increase in population of the world continuing, it is essential that we should investigate how safety and stability may be threatened, and regulate the activities in order that irreparable harm is not done. At least we must take this aspect of human activities into account in our schemes for the future. The author we have quoted sees, as a result of his studies, a tendency for humanity to reverse in the future the process of denudation, and he concludes on a very pessimistic note, saying that, "Man's most permanent memorial is a rubbish heap, and even that is doomed to be obliterated." This conclusion seems to us to err on the side of graphic exaggeration.

We may next turn our attention to Man's influence on plant life. So many factors condition the life of a plant that it is difficult to isolate Man's effect from that of other conditions, but the most cursory examination will convince us that the total effect is enormous. We have only to consider the question of forests to realise this. The gradual deforestation of the world has been justly described as "one of the most important economic facts of the present times." We know that comparatively recently the British Isles was a forested area, that it has been devastated by man within historical times, and further that trees have a marked effect upon climate. So fundamental may these changes be, that enlightened Governments are making serious and world-wide efforts to make good the losses of the past. Large areas are being afforested in an effort to compensate the senseless destruction that has been performed at the dictates of commerce with never a thought for the future. Between 1919 and 1924, 39,469 acres of land were planted with young trees under the auspices of our own Forestry Commission. There are thirty-four planting areas in England and Wales, and twenty-eight in Scotland, which are sufficiently big to carry forests of economic size. In the Thetford district there is an area comparable with the size of the New Forest. Wherever a civilised community settles there is always a destruction of plant life. Not always is the destruction so obviously foolish as in the case of the forests.

We may also see a compensating process going on side by side with the destruction. Man sows where he has reaped, and the crops he raises again give us staggering figures for their total bulk. Large centres of population need supplies of plants within comparatively easy reach, and need the crops to be certain and sure. Hence we find that Man has exercised a selective influence, and at the same time has stimulated the slow changes of nature by protecting his plant protégés from other plant and animal enemies, and provided the best conditions for propagation at the times when they are most needed. We may illustrate the point by reference to the wheat crop. The wheat plant would very soon be a rarity in the world if the protection of man were withdrawn. Its more sturdy relatives the grasses would easily master it, and choke its early growth. With the help of man it flourishes, and the more virulent and less useful crops have been banished. Man's effect can be seen very clearly in the case of one variety of wheat, the Marquis wheat. One seed of this variety was sown in the year 1903, and its product stored in an envelope during the ensuing winter. In 1918 the crops of North America amounted to three hundred millions of bushels of

Marquis wheat, mainly at the expense of Nature's crop of Prairie grass.

Of the innumerable species of plants that cover the face of the Earth, very few have found favour in the sight of Man. There are about three hundred species of cultivated plants of any importance, and these are occupying more and more space as time passes. We can foresee a time when the campaign will end with the total extinction, outside preserves, of all natural species in favour of the cultivated varieties. Again we find that we are dealing with a problem of world-wide import. There is a very delicate balance between plant life and the soil in which it thrives, and if this balance be upset, then disaster must follow. We see so many instances in the past, where the present has been the only consideration, and drafts have been drawn from the soil as if the supplies were unlimited. Such procedure is but creating difficulties for the future, and wisdom would dictate that future developments should be carefully considered and regulated, to produce the maximum benefit to the present generation, and yet hand on an unimpaired inheritance to those that will follow.

When we turn to animal life we find that similar considerations apply. Man's effect has been twofold —he has selected and helped those animals which have proved useful or have taken his fancy as pets, and he has destroyed the others. The plains of America were black with wild herds, where now the more docile cattle roam in the service of Man. As a hunter he has swept species out of existence, and variety is seriously diminished. Some two hundred species of animals have been domesticated, and of the remainder the number is fast decreasing. Already we have a long list of animals that have become extinct within historic times, and the modern establishment of huge game preserves is an attempt to retain a representative collection of the existing fauna of the world.

"Looking forward into the future we may see the tide of human expansion ever spreading, with here and there an occasional ebb, and in time all the living things that are not serviceable to man or cannot adapt themselves to the conditions he imposes will dwindle and disappear. The arts of breeding and acclimatisation will produce new and curious forms to supply the needs of food, of raiment and convenience which only life has the requisite cunning to produce and only human life the restless activity to require."

This forecast of future, wholesale destruction of what is, and its replacement by new material, has a very high degree of probability. In considering it, however, it is necessary to emphasise the necessity for a wise caution in the steps that are taken. The relationships that exist between the various fields that we have considered are very delicate and very intricate. Blundering experiments are doomed to failure and their results are likely to be accompanied by untold suffering. At first sight these matters present a simplicity that is most misleading. For example, the birds eat our crops, and to save this loss it seems so simple to shoot the birds. Such action, however, only gives an advantage to the rats, mice and such small deer, which form a portion of the diet of birds of prey. The caterpillars also rejoice, and make the best of the time given them, and plagues of these creatures swarm over the crops and the last state is worse than the first. This is a well-known example, but the principle which it illustrates has many applications some of which are very difficult to discover.

Man's active campaign to remodel the world to his own needs and tastes must be conducted under the expert guidance of specialists who, studying each problem as it arises, make certain that the adjustment of one factor is accompanied by the adjustment of all the other relative factors. Otherwise the world is likely to be swept with horrors that will make the Great Plague and the Great War seem very minor affairs.

Finally, we must refer to Man's action on Man himself. Here we tackle a problem of very great difficulty, the problem of social organisation. We do not propose to trespass into the realms that the politician claims as his own, but science cannot entirely ignore this very debatable area. For the present, however, we are mainly concerned with the biological side of the matter, which as the ages pass, Man is ever making more determined efforts to control. This control is specially directed to the education of the young. Always an attempt has been made to mould the young of the community to the type that, at the time, seems best. Vast educational schemes have been organised. Philosophers have devised system after system. The best and the highest in the land have been placed, generation after generation, at the disposal of youth—and yet thousands of years of progress, two thousand years of Christianity did not prevent 1914–1918. "We learn only by experience," is the popular answer to such a poser as this, a cry that the biologist has gone far towards proving utterly false.

We may grant that to-day we know almost the mechanism of heredity, which surely is a prefatory step to its control, using the word control to mean working in harmony with known processes. We already see in the tentative efforts set up in the name of eugenics the way in which Man's thoughts are turning. Admittedly we are only just beginning, and we are suffering from an excess of morbid imagination from certain quarters where these attempts are viewed in the light either of the preconceived idea that they are wrong according to some ethical code, or are painted in such lurid language as to disgust the saner sections of the population. The professional breeder of animals builds up a strain of pedigree stock, valuable for some particular quality, and his practice is largely a process of hit or miss, for much of his work is directed by blind choice only. Can we not see a possibility, with increasing knowledge, of replacing the blind chance by scientific precision and giving to Man a power over life which he has never had before. To his intelligence and reason must be left the decision as to whether the result will be good or evil. The responsibility will be truly great, but knowing what Man has accomplished and having infinite faith in his future, we feel that the responsibility will be wisely borne, and that we shall attain to a real Utopia—a land fit for heroes.

To some, the prospect of the future does not seem at all pleasing. The world is very beautiful as it is, and the useful things desired by humanity are but blots on the landscape. Surely this is a false view, for there is that in Nature which triumphs over all interference, a force that may be diverted, a force that may be tamed but never conquered. At our most pessimistic moments let us turn to Italy. We see it through the soft mists of poetry, and on the flaming canvases of the artists. We see it as an ideal of beauty. Let us not forget, as we go into raptures over its classic groves and vine-clad hills, that all but the bare soil of Italy was brought there by the hand of Man long years ago, and the "native vegetation only holds its own, a stunted remnant, on the mountain tops."

CHAPTER XI

THE TOM-TOM OF THE TWENTIETH CENTURY

"*The long shout runs echoing through the skies.*"
THE ILIAD.

ALTHOUGH individual movement does not constitute a very rigid line of demarcation between plant and animal life, it does, for all practical purposes, mark a very characteristic peculiarity, when we think only of the higher animals. A plant stakes out a site and in its fight for all that is useful in that space endeavours to smother and kill all intruders. An animal roams the surface of the Earth, sucking what benefit it can here and there, within the limits of climate to which its nature is fitted. In the attempt to accomplish this at the highest efficiency, many lines of specialisation have been followed, making for facility of movement in a special environment. We may instance that weirdly shaped little animal the Mole, which has undergone striking modifications to help its life under the ground. Its bones have been altered to give its front legs the power of Man's dredging machines, and its eyes and ears have become very rudimentary affairs. It is admirably fitted for its mode of life, which, however, is a very special one and limited to a definite area; very small changes make life impossible for the Mole.

We can see how, in the early days of animal life, facility of movement tended towards improvement, using the word in the human sense. The animal in virtue of its roaming would be coming into contact with a greater variation of environment than the more stationary plant. Each new condition would create problems, and dawning intelligence would be sharpened and made richer in inherited tradition by the tackling of these difficulties. What perhaps in the first instance was a blind impulse to escape an enemy or a vague reaching out after better and larger food supplies would become an intelligent appreciation of the benefits of motion. As we can watch a growing child ever widening its exploration of the home, and at the same time widening its own mental structure, so we can imagine the early animals ever creeping farther away from the primordial ocean in which they arose, and progressing to the variety and advanced state in which we find them to-day.

With the passage of ages they dug into the ground, they climbed the trees, and some developed the power of flight. Slowly and surely the perils of distance were overcome. There is a necessary corollary to this. It is not good for man to be alone, and it is impossible for life to continue for solitary individuals. It appears that even those primitive creatures that increase and multiply by the simple process of breaking into two pieces, cannot continue the process for ever and ever. In order to keep up the vitality of the race it appears that it is necessary for two individuals to unite and so give rise to a combination from which a new generation can arise. Sexual reproduction, concerning two individuals, was a very early introduction to the life of the world. In so far as it concerns two individuals it makes a meeting of these a necessity.

Roaming about would tend, however, to keep individuals apart, and we may imagine, for we *know* very little, that such meetings were at first more or less a matter of chance. This means that very often total extinction must have taken place, and to avoid such waste we get the development of means of communication. Crude as these may have been at first, almost nothing but simple chemical stimuli, they have developed and given us wonderful structures such as the scent-issuing organs of a female moth, by which she can attract her mate from far off; such as the strange strident noises made by the insect world, produced by strange mechanical devices attached to living organisms; such as the croak of a frog, the wail of a wolf, the howl of the hyena, the song of the bird, and culminating in the speech of Man.

It is not our purpose to trace the development of speech, or any of the other animal languages, which undoubtedly arose from primitive cries from mate to mate. The evolution of these cries has given a wider significance to life and made possible developments otherwise impossible. It is one more example of economy in Nature in which the most is made of every happening. Speech has its limitations, however, especially in regard to distance. There is a definite distance beyond which communication by speech is impossible. The distance will vary with the individual and the atmospheric conditions, but it is a limitation that the earliest Men appreciated and set out to overcome. Speech is also a thing of the moment. It is uttered and gone. To these limitations we may attribute a language of signs, bodily signs at first and later in the form of symbols on stone, brick, bone, skin, parchment and paper. We are but touching the fringe of a field of wide interest and will be content to notice the advantage that these developments conferred on the human family. One particular development has special interest for us because it parallels in primitive races the latest extension of means of communication in the most highly civilised races of to-day.

The reverberating notes of a drum will carry far into the still air, and a use of this phenomenon is found among most primitive races alive to-day. So wide, in fact, is this found as to suggest a common origin far back in the past, although this is a conclusion to which we must not attach too much importance. It is quite possible that separate races invented the process on their own. It is not just a case of the use of a drum as a warning cry or a rallying note for defence. There is a drum language, and Frobenius tells us that in Central Africa the natives use this language for many purposes. "By means of the sounds of the drum, which are heard miles around, the villagers converse on most familiar subjects. They bully each other, declare war, make inquiries about each other's state of health, hold palavers and courts of justice, and even abuse each other. . . . The language itself is introduced and specialised by beats on different parts of the drum. There are four different notes, which may be imitated by the mouth and then produce a language that differs absolutely from that in daily use." Such means of communication are not confined to Africa but are found in all parts of Oceania and the Americas, though it reaches its highest development in the western parts of equatorial Africa.

It is easy to see the advantages conferred by such an extension. It makes possible that co-operation and organisation that distinguishes the human community from other animal packs, and it is to co-operation and organisation that we must look for progress. We will rapidly pass over the further stages of progress by civilised races, noting the establishment of definite postal services made possible by the invention of written languages, and extended by the invention of printing. We see further extensions with the coming of the railways and the discovery of the possibilities of the use of electricity in the telegraph. So we come to our own times, when we see the highest civilisations playing, like little children, with the wireless tom-tom of the twentieth century.

Of wireless literature there is almost a surfeit, and we have no intention of adding further to this mass of technical dissertation. Wireless telegraphy and telephony illustrate, however, one of the main theses of this book very vividly, and it is from the point of view of its addition of a new organ to the human being that we would consider it. It is of interest to turn for a moment to the history of this fascinating subject. The wireless activities of to-day give us the use of an organ which bids fair to equal, if not more than equal, in value any other structure possessed by the animal creation. To evolve such a structure by the usual methods of evolution would have taken vast periods of time. Man, however, works by quicker methods. In the middle of the last century the masterly experiments of Faraday, and the mathematical treatment of them by Clerk Maxwell, led to the foundation of a theory of electricity. This theory opened many fascinating possibilities among which was the idea that it should be possible to propagate electricity through space by waves through the hypothetical ether. Experimental proof of this theoretical forecast was provided by Hertz whose work was announced in 1888. He managed to get actual communication across a few feet of his laboratory, and thus, less than forty years ago, the first wireless transmission was performed. The experiments were crude compared with modern achievements, and they surprised even Hertz himself. When he managed to get sparks from his receiving apparatus a little over ten yards from the transmitter, he said, "It appears impossible, nearly nonsensical, that these sparks should be visible, but in a perfectly dark room they *are* visible." The impossible and the nonsensical, however, rapidly increased in efficiency and was soon attracting the attention of a wider field than that of pure science.

Between 1889 and 1891 notable improvements in apparatus were made. In 1891 *The Electrician* suggested the practical utilisation of wireless. In 1894 Sir Oliver Lodge was able to demonstrate its use over considerable distances, and two years later the famous Marconi appeared on the scene with his brilliant series of experiments on Salisbury Plain. In March 1899 communication between the South Foreland and Wimereux, near Boulogne, was established, and in 1900 transmission over a distance of 85 miles was hailed as a triumph. A year later *Nature* summed up the position in relation to the new activity in the words, "Even now we can scarcely call wireless telegraphy much more than an experiment." In the same year messages were sent from St Catherine's Point, on the Isle of Wight, to the Lizard in Cornwall, a distance of 200 miles, and late in the year it was claimed that signals had been sent from the Poldhu Station to Newfoundland. In the following February the Poldhu Station kept in touch with the American liner, "Philadelphia," for a distance of 1009 miles. On December 22nd and 23rd the first messages sent across the Atlantic were published in England. In March and April of 1903, *The Times* published 267 words sent from America, and in the following October the "Lucania" was supplied with news by wireless from New York to Liverpool. In January 1904 the Cunard Line commenced publication of an ocean daily paper with news supplied by wireless—all this within sixteen years of Hertz's experiment.

The advances that have been made since those days are wonderful in the extreme, and it is of interest to set down for comparison a few snapshots of the present:

The Times, 14th July 1925:

"*That there is a general movement towards the development of broadcasting . . . was most gratifying to those who believe that broadcasting can do possibly more than any other agency to bring about conditions necessary for peace, commercial prosperity and individual happiness; at the same time it gave grounds for anxiety. The ether is free, but it is limited in its capacity. What guarantee was there that in the next broadcasting season the European ether would not become chaos?*"

A congested ether in forty years!

. . . .

The Daily Mail, 30th April 1925:

"*Within a few weeks a woman will be shouting down the leather-lunged porters of St Pancras Station. . . 'St Albans, Luton, Bedford, Kettering,' boomed the cultivated Great Voice; 'St Albans first stop,' in syllables distinct enough to make a porter really skilled in unintelligibility quite furious.*

"*The voice could be traced through five super-loud speakers in the roof and down a cable to the sidings outside the station. Here an official sat at an 18-valve transmitting set that is almost a replica of a B.B.C. broadcasting plant.*"

. . . .

Daventry Wireless Station.

Opened 27th July 1925. *Occupies an area of* 25 *acres. Has two masts* 500 *feet high. Power* 25 *kilowatts to the oscillator.*

. . . .

Ocean Wireless Telephony.

Passengers on the "Princess Ena" "when approaching Southampton were able to converse with people in towns so scattered as London, Glasgow, and Cardiff."

Broadcast from moving train, 30th June 1925:

"*At* 8.50 *the B.B.C. switched over to the footplate of the locomotive that had hauled the Scotch express out of the London terminus twenty-five minutes before, and listeners heard first the roar of the train and then a conversation between officials of the Company and the B.B.C. travelling on the locomotive. The train was then approaching Hatfield and travelling at seventy miles an hour. Although the noise of the engine sometimes drowned the sounds of speech, the broadcast was accomplished as planned, and the momentary failures rather increased than diminished the idea of reality of what was being done.*"

. . . .

At this we may leave it, although it would be possible to continue such extracts almost without limit, pointing to the wonders and marvels of wireless. Even then we are forced to the conclusion that we are still at the beginning only of its usefulness. We cannot doubt that in time every broadcast programme will be accompanied by its own wireless kinematograph illustrations, and so we shall not only hear but see by wireless; that electrical power will be transmitted likewise without wires is another possibility. These are but two of the likely extensions that the future will see, but they are sufficient to arouse enthusiasm. Still these and most of the wonderful forecasts that have been made concern only mere mechanical advantages to which we must not pay too much attention, or we get a distorted vision of the future that has been aptly described as more like a plumber's paradise than a Utopia.

We cannot stress too much the cultural side of these developments. Wireless is putting the individual in touch with the whole world. Already it has become an international question, and conferences are being held at Geneva to consider the many problems that arise as to its administration. Such "getting together" of the nations of the world, whatever the subjects on which they confer, can but lead to a better understanding of national aims and aspirations, and on this basis it is possible to build a real structure of peace.

Further, wireless has opened a world of interest to the humblest members of the community. For a few shillings it is possible to get into touch with all that is best in the realms of art, literature, music, and science. The workers of the world to-day are claiming a right to leisure, and the difficulties that arise when this claim is admitted are very great. There is a tendency to differentiate work and leisure, and crave for the life of the so-called idle rich. For the senseless round of social flippancies that this very small class of beings engage in, a special training is necessary. One of the essentials is a brain that works on a very low level or does not work at all. Such a life is as foreign to the average Englishman as anything we can imagine. We are essentially an active race, bodily and mentally, and the old adage that "Satan finds work for idle hands to do" is as true to-day as ever it was. Leisure, which the worker earns, needs employment if it is to have any value, employment for brain as well as brawn. We can see no more useful form of mental activity than that which may be stimulated by the wise administration of broadcasting.

In wireless, as we see it now, and as we can foresee its possibilities in the future, Man has used his mind to give to his body another "extra limb," and one which will be used for the progress of the race to a very marked extent. The whole world can be brought to the side of our armchairs. News of our neighbours can be rapidly disseminated. To the strength of the lion, the swiftness of the deer, the eye of the cat, we add on a

" sixth sense " of knowing what is happening anywhere and everywhere at any time—and this wonderful addition to our possessions, in no way complicates our bodily or mental structure, in no way leads it along narrow lines of specialisation, but leaves us free for further expansion along lines of which we have not yet imagined.

CHAPTER XII

OUT OF EVIL COMETH GOOD

"*A tiny trickle, a roaring torrent may become : the flood confined may turn the mill, and so man's work be done.*" ANON.

WAR is not a pleasing subject and the sooner we forget our all too recent and terrible experiences the better it will be for us. Yet a very short chapter must be devoted to certain aspects of the subject, for so rich in lessons for humanity was 1914–18 that it would be criminal folly not to point the moral.

As far as science is concerned our reflections are two-edged, for, on the one hand, we have the accusation that science alone made the horrors of war possible, and again as we look back we can see that the final legacy of all our sufferings will be the ultimate good of humanity. Let us at once deal with the accusation ; for if the work of science is to make war possible then it would be better for the chemist and the physicist to take up some other occupation and leave their fields of work alone. We recognise that humanity has embarked upon a line of progress from which there is no turning back. We can never go back to nature any more than we can fly to the Sun, if by going back to nature is meant a return to the social conditions of primitive culture. That the organisation of civilisation will change in the future is certain, that it will improve in every sense of the word is likewise to be expected, but the alteration and the improvement will have to be along the definite lines of advance that have been selected. Along these lines science in its applications is not a mere external growth but an integral part of the whole foundation. Explosives are a necessity for mining and quarrying, drugs and poison gases are factors in modern commerce. That these things were used for the evil purposes of war is no concern of science. One might as well attempt to blame Nature for the production of flints from which ancient Man made his crude weapons.

The scientist claims justly that his work is the basis of all the physical needs of modern civilisation. Our modern structure rests on a basis of science, and to that structure science is ever adding. Each addition, it is claimed, spells further progress. The claim, however, does not stop at mere mechanical and material advantage. On the much more important side of the mental life of the community, science has made its due contribution. It is giving an ever wider and deeper understanding of the Universe and thus fitting mankind for the environment in which he finds himself, and providing the materials for a philosophy based on sounder foundations than of old. It is providing a method that will be of incalculable value for tackling the problems that confront humanity at the present time, as also those which will arise in the future. Whatever our view may be, whether we favour the present trend of progress or whether we sigh for the so-called good old days, we have to realise that here and now we live in an age of science and the immediate task is to make the best of what is. Science in its widest aspects is a search for truth, and so far as it is honestly pursued, it can have no other result than good for the whole of humanity. After all, the Marne was less of a ghastly affair than the blood-soaked fields of Waterloo.

Turning to the other side of the picture we may suck a measure of consolation from the lessons that War taught us. In a time of stress we turned from the vapourings of the politician to the abstract utterances of the scientist. Frankly unprepared for the task which we had undertaken, and opposed by a nation that was, we quickly realised that the crucial field of battle was within our laboratories. The scientist, who previously had been starved, was given unlimited money and was able to make rapid progress. Not alone was this work confined to the production of means for destruction. Certainly that was the aspect of the work that most caught the popular imagination, and we counted our store of shells more anxiously than our store of gold in the vaults of the banks.

Modern warfare does not consist solely of slaughter. There are millions of non-combatants to be maintained alive and well, and the intricate and delicate balance of world commerce was seriously disturbed by the rigours of war. Our tight little island was cut off from many of the supplies that were necessary for its existence and the chemist alone could supply the necessary substitutes. We may instance the very humble example of the rapid increase and advance in the production of butter substitutes, which grew from a very despised position to one of high repute. To use margarine before the war was almost a social stigma. A more scientific example is that provided by optical glass. Of this industry we knew very little before 1914, but, when deprived of all our supplies at a time when we needed them most, our chemists were very soon producing optical glass equal in quality to any that we had ever imported from Germany, and at the same time laying the foundation for a post-war trade of no mean importance.

In the realms of medicine amazing progress was made, not only in the preparation of drugs hitherto imported, but also in the study of health conditions. Never was an army put into the field freer from disease than the expeditionary forces from England and America. Restricted food supplies also emphasised that group of disorders that we call deficiency diseases and valuable observations were made on these, contributing to the highly-important work on vitamins that has followed the war. Wonderful surgical advances were also achieved and we may instance facial surgery. Quoting from a recently published report: "Men with jaws and faces smashed to shapeless pulp have been recreated in human form. . . . The value and wonder of this work cannot be expressed in words. For the patients doomed, as they thought, to mere existence . . . it has meant rescue from a living death." The need for such work is naturally decreasing but the knowledge and skill gained remain for all time. The psychologist was provided with unique material for study, and valuable information was gained of morbid mental states that has already been of great service, and in the future will have even greater influence.

At this we will leave it, stressing the fact finally that War, a modern addition of civilisation to the disorders of the world, has yet played its part in the advance of humanity mainly in that it has given a vast multitude a very clear insight into the fundamental connection between science and modern social organisation, and further has contributed material gains, the full effect of which we have not yet realised.

CHAPTER XIII

BOTTLED SUNSHINE

"*I suppose none of us recognise the great part that is played in life by eating and drinking.*" ROBERT LOUIS STEVENSON.

THE individual who prides himself on being a normal member of the community has a wholesome contempt for what are termed "food faddists." The contempt is often tinged with admiration for those who have the courage of their convictions and go about the world labelled as vegetarians, and suchlike designations, some polite and some otherwise. However normal we may be, we cannot but realise the enormous importance of this question of diet. Our own individual experiences of the drastic consequences of unsatisfactory feeding are vivid enough to make this evident to us. Again, in cases of illness we have it impressed upon us by the attention that "the doctor, the nurse and a great many more" give to diet charts. Fortunes, made in Harley Street, often rest on the foundation of a prescription that substitutes a wise diet for the dictates of a jaded palate.

The history of dieting through the ages would be a fascinating subject, and it would emphasise the wide influence that food has had upon the human race. It may not be necessary to "live to eat," but the reverse is certainly strictly true. We may illustrate this influence by one concrete example. Four hundred years ago, our ancestors knew little or nothing about the winter feeding of cattle, and were forced to slaughter and pickle their surplus stock at the end of the season. Now, salt beef for breakfast, dinner, tea and supper is not an inviting prospect, and the palate of Western civilisation craved for the fragrant spices of the East. So we have pictures of those days when long caravans crawled over the plains of Persia, across the dusty deserts of Arabia, along the north coast of Africa, where, at primitive ports, the Arab owners bartered their spices with the merchant sailors of Europe. The trade was a highly profitable one for the Arabs, who discouraged Western rivals by a process of blood-letting that proved particularly effective. The hardy sailor men, failing to reach India safely by land, set out to seek a route by sea. Columbus, with a touch of genius, sailed west to get to the east, and literally stumbled across the Americas. Possibly he was not the first Westerner to visit these shores, but he blazed a safe trail along which a mighty exodus began, that has continued to our own time. So we have to-day other pictures of mighty nations on either side of what has become a mere " herring pond," from the edges of which miles of docks thrust out to receive the products that fill the busy marts, and engage the attention of a myriad business men—all as the result of a craving for spice.

We will leave the romance of food and turn our attention to certain scientific aspects of the question, which have important applications to-day. The problem that faces every household is the satisfying of human desire in accordance with the rules of health. We may point out that the idea that there is a natural diet to which the animal will turn by some wonderful process, labelled instinctive, is founded on very slender grounds. Even wild life makes mistakes, and ages of catering have left the human family very dependent on direction in the matter. Until comparatively lately the literature was almost entirely the propaganda of this, that, and the other fad. The latter part of the last century saw much good work done towards a scientific classification of foods. Let us consider this classification in the light of present knowledge.

Under the name of PROTEINS is grouped an endless variety of foods. The proteins—of which lean meat may be taken as typical—are complex substances, the complete chemical structure of which is by no means known with certainty. They form part of every animal body, but the animal is unable to make them, unless supplied with some other form of protein. Plants manufacture simple forms of proteins from raw materials gathered from the soil and the atmosphere. All animals live either directly or indirectly on plants, using the plant proteins to build up the more complex ones needed for their own bodies. The first step in this building process is the operation which we call digestion, during which the proteins absorbed are split up into complex substances known as *amino-acids*. These amino-acids, although very complex, are simpler than the proteins, and pass through the walls of the digestive apparatus into the blood stream, and are so carried to every part of the body. The tissues of the body *select* from this stream what they need for the purpose of growth or renewal. It is important to stress this selection, for it enables us to realise that this protein food, so necessary for the body, may vary not only in quantity, but also in quality. All proteins do not give the same amino-acids during digestion, and it may happen that a diet rich in protein may just lack the very ones that are vital for the particular organism concerned.

Truly it has been said that "cannibalism is the most economical method of nutrition, as for each part of muscle protein in the food, it is possible to build up one part of muscle protein in the body." We see, therefore, that not only must the supply of protein be correct as to quantity, but it must also be correct as to kind, in order that the body may be kept in health. Common sense indicates that the flesh of animals is the best supply of proteins for our use, as it most closely resembles our own tissues and will, therefore, in digestion provide the particular amino-acids required.

Another large class of food-stuffs are called CARBOHYDRATES, and starch and sugar are the principal examples of this class in the human diet. Starch is derived from cereals, peas, beans and potatoes mainly, and sugar occurs in fruits, honey, milk and the manufactured articles made from the sugar cane or beet root. The use of carbohydrates in the diet is very simple: after passing into the blood stream they become the source from which the energy necessary to run the complicated machine we call our body is obtained. Every activity from birth to death requires a supply of energy, and as a motor absorbs petrol so do we absorb carbohydrates. In the mechanism of the body is provided means for the slow combustion of the carbohydrates, whereby energy in the form of heat is liberated. Common sense, again, will indicate that the amount of carbohydrate required, will depend upon the nature of the life we lead. An active individual will require more than one who leads a passive life, but age, sex, weight and climate are also factors which must be taken into consideration.

We recognise also under the term FAT another class of food which includes the oils as well as the more solid substances that the word suggests. These also act as fuel, but they cannot entirely take the place of the carbohydrates. They are in fact an inferior type of fuel having, as it were, a higher proportion of " ash " which tends to clog up the organism. A mixture of fat and carbohydrate helps, however, to complete combustion. The fats " burn " more slowly than the carbohydrates in the body, and are thus more sustaining, and they can be easily stored as a reserve of fuel to be called upon when needed.

Then we have a varied group of substances classed as SALTS. These are inorganic substances, occurring in relatively small proportions in all food supplies. We may add water which is contained in all fresh food. These inorganic substances are required for health and will be provided in the requisite quantities in the average mixed diet, with the possible exception of common salt, which we add according to our individual taste, which is probably a very good guide to our needs.

Besides these main classes of food there is a large variety of odds and ends, which we absorb, and which make up the bulk of our food. Some appear to be absolutely useless and others in such minute quantities as to suggest that they are of little importance, but here it is necessary to write with caution.

From the above summary it will be seen that the average mixed diet of our nation provides some at least of all the necessary ingredients—proteins to build up the body, carbohydrates and fats to provide energy, and salts to maintain health. Twenty-five years ago it was common opinion that successful feeding was only a question of regulating the quantities of these ingredients in a manner suitable for the needs of the individual. Life, however, strikes us most forcibly as an activity, and it was natural that more attention would be paid to the energy sources in food supplies than to the other kinds of food. This question has been the subject of very careful experiment. It is possible to measure the exact amount of energy that any particular food can produce, and also to determine the amount of energy that is needed by the individual for any particular purpose. It is, therefore, possible to construct a kind of balance sheet, between energy supplied and energy required. This energy quantity is usually expressed in units of heat called *calories*, and many a young wife has been very worried over the calculations involving these.

Experiments in this line will obviously take the form of feeding operations carefully observed and recorded. A difficulty at once arises here. With the exception of sugar or salt we never eat pure foods, in the sense that they are all protein, or all carbohydrates, or all fat. Foods are mixtures, all or some of the classes will be contained in any natural diet. To estimate exactly the values required, it is necessary to prepare pure samples of these products by long and complicated processes. When an animal is fed with these pure products, in the proportions that is necessary for the building up of tissue and the supplying of energy, the surprising result is obtained that the creature under experiment does not enjoy good health. Various recognisable diseases appear with unfailing regularity. The only possible conclusion is that in the process of purification some constituent of natural foods is lost.

We may take, for example, the case of scurvy, that breaks out in an animal fed on pure food-cultures. It has long been known that scurvy results whenever certain kinds of food are missing from the diet. It was at one time very common among sailors, who were unable to obtain fresh fruits or vegetables during long sea voyages. It seems to have been known since the early years of the seventeenth century that the juice of a lemon given in small quantities regularly would overcome the lack of fresh food. Another terrible disease known as beriberi is also due to a deficiency in diet. In 1885 it was proved that beriberi resulted from the use of polished rice as the main diet. Sufferers to whom the polishings, or even an extract of them was given, recovered; and the disease was stamped out when the unpolished rice took the place of the polished product. These are not the only diseases known to be due to the lack of some particular kind of food, or some particular part of a food-stuff. In general they are known as *deficiency diseases*, but it was not until the present century that very much attention was given to them.

When once careful attention was given to the matter it was very soon realised that "no animal can live upon a mixture of protein, fat and carbohydrate, and even when the inorganic material is carefully supplied, the animal cannot flourish. The animal body is adjusted to live either upon plant tissue or other animals, and these contain countless substances other than the proteins, carbohydrates and fats." In 1911 Funk claimed to have isolated a definite substance which was capable of preventing beriberi. This anti-beriberi substance he named *beriberi vitamine*, supposing it to belong to a class of substances that the chemist calls amines. Funk considered his substance to be an amine necessary for life. In the light of subsequent research it is doubtful whether this claim for isolation is correct, but the name, shorn of its final " e," has remained with us to denote a constituent of natural food that is essential for life.

At the present time we certainly do not know what a vitamin is, and for that reason the name is probably unfortunate, for it suggests a definite type of substance, but it is so common in the literature and so established in popular use that it will probably survive any attempts to alter it now. Our knowledge of vitamins is derived entirely from feeding experiments carried out on animals and men. Such work needs very careful arranging, in order that false conclusions are not arrived at. In general the method is as follows: a diet consisting entirely of pure preparations is used to which is added or subtracted some definite constituent. The physiological effects of the diet are noted, and the results produced by additions observed. Thus having obtained a healthy set of animals by feeding them with a suitable diet, it is possible to induce an attack of scurvy or rickets or any of the deficiency diseases by withholding some particular constituent of the diet. The patient can then be supplied with various articles of food, and a list made in this way of those which contain the necessary factors for curing or preventing particular diseases. Many long and careful researches of this nature have been undertaken during the past fifteen years, with results that are proving of vast importance.

The results so far enable us to recognise the existence of at least three vitamins, which are usually referred to as the A, B, and C factors. The recognition, we must remember, is of their existence: we have never isolated them nor do we know what they are.

The *A-factor*, also known as the *Fat soluble A-vitamin*, is essential for growth and the prevention of rickets and other diseases. Among food-stuffs rich in this vitamin are cod liver oil, butter, cream, egg yolk, animal fats, herring, mackerel, salad vegetables and whole meal bread.

The *B-factor* (*Water soluble B-vitamin*) is also essential for growth and its absence from food supplies is responsible for beriberi. Its main sources are found in egg yolk, wheat germ, yeast, liver, pancreas, and nuts.

The *C-factor* (*Water soluble C-vitamin*) is a necessity in human diet, and for certain other animals, for the prevention of scurvy. It is found in lemons, raw cabbage, most vegetables and sprouted seeds.

The sources given above are those particularly rich in the particular vitamin concerned. The vitamins are, however, widely distributed in natural foods, many varieties containing all three. On the other hand, there are foods which bulk largely in our national diet, which contain little or none of the vitamins. Among these we may specify margarine, tinned meats, cheese, bottled and tinned fruits, egg substitutes, and white wheaten flour. Another point must also be noted here, that the vitamins in any food supply may very easily be lost in the processes of preparation for the table. The A-factor is not destroyed by the ordinary processes of cooking, especially if carried out in a closed vessel; but exposure to the air, especially if heated at the same time, rapidly destroys this vital constituent. B- and C-factors are easily soluble in water, and in the usual English method of cooking vegetables most of the valuable vitamins go down the sink. Raw fruit and vegetables are much to be preferred to cooked ones, and steaming is a better process than boiling in a lot of water.

It is not our intention to write a cookery book, but it is only logical to make this description practical by general advice to the careful housewife, who in the past calculated calories and is now faced with these intangible vitamins. The golden rule is vitamins every day, every meal if possible. "There should be a sufficiency of milk, vegetables and fruit, thereafter, cereals, meat, fats and sweet-stuffs according to taste, the financial resources and the digestive powers of the individual and according to his needs in respect of energy," and we may interpret that in this way, "Spend at least as much upon vegetables and fruit, and at least as much upon milk, as you spend upon meat, fish, cereals and sweet-stuffs."

The question is often asked, "Is all this vitamin nonsense just another food fad?" and the answer is an unqualified negative. The conclusions rest upon a sure foundation of experiment, verified again and again. No one imagines that we know now all that we shall know in the future, but the progress made so far is along definite and sure lines. It must be realised that the deficiency diseases that we have specifically noted above are extreme cases. They are the logical outcome of the continued elimination of one or more of the vitamins. Such complete elimination will only rarely take place under conditions of civilisation. The lists of vitamin-containing food is a large one, and it would be a curious diet that did not contain some at least of all of them, but the continued experimentation has led to another result of great importance. Not only must all the vitamins be included in the diet, but there is a minimum for each that is necessary for health. If for any factor the diet falls below this minimum then ill-health results. It may not be the extremes of illness such as scurvy, beriberi or rickets, but it will be manifested in the general lowering of the tone of the body, with the accompaniment of lassitude, eternal fatigue, headache and general depression. The "kruschen feeling" is really dependent upon maintaining the minimal quantities of all three factors. The minor ailments of life, the times when we are off colour, fits of depression, mental stagnation should send us to a study of menus, and not to a bottle of tonic. The vitamins have been described as a team, working in and for us. What they are and what precisely they do is not known, but they have been happily compared to the spark that sets off the explosive mixture in a petrol engine. As far as is known an excess of vitamin does no harm, and may possibly be stored up.

Finally, we note the latest steps in this fascinating work and thereby justify our chapter heading. This is the discovery that lack of the A-factor can be compensated for by the provision of ample sunlight. The health-giving properties of sunlight is no new discovery, it has been recognised for ages, but this definite aspect of it opens a vista of possibilities that almost stagger imagination. The vitamin content of a food can be increased by exposure to sunlight. Will it be possible in the future—but we are trying to write sober science and must curb poetic fancies. Then on top of this comes an announcement of anti-vitamins, things that contend with the vitamin and stultify its effect. It is suggested that if this prove to be really the case then it can be met by the proper mixture of foods, and that bread and butter, porridge and milk are not mere accidents but an association that is a rigid scientific necessity.

We must leave to the future the working out of these details. There is already much that can command our earnest attention, for 1914 taught us that we have much C3 material that should be eliminated from our nation.

CHAPTER XIV

THE LAST REFUGE

"*O that I had wings like a dove; for then would I fly away and be at rest.*"
THE PSALMS.

As we study the realms of nature we are sometimes impressed with the quiet and calm that we observe; when sky and landscape seem only masses of tones that blend marvellously in the mid-day haze and all life seems "one sweet song." Again, we are appalled as we see Nature "red in tooth and claw": when the purring tiger become fury incarnate at the dictates of hunger. This latter view is often very much over-emphasised, and unduly exaggerated. We are apt to interpret the horrors that we see in the light of our own delicate and shuddering nervous mechanism. We picture the lower animals creeping and crawling in constant fear of death from anything big and hungry that they may meet or that may set out to find them. That this is a false interpretation we cannot doubt when we view it calmly. The death is very sudden and unexpected as a rule, and even mutilation does not produce the pain that we should experience under similar circumstances. The lizard will shake off its tail voluntarily, as a kind of side-show, to put the pursuer off. Many creatures grow new limbs to take the place of those lost in combat, and do not seem to suffer in the process. Also it is highly improbable that anticipation, which is more than half the battle as regards pain, plays a very important part in these creatures of low mentality. More than likely it is entirely absent, for it is a function of imagination which even in the human race is a late development.

Nevertheless this side of life has entered into the evolution of life to a considerable extent. It is indeed responsible for much that we see around us in the forms of animal life. The deer needs no powers of skimming over the surface in order to browse on the verdure of the plains, but has developed this power under the stimulus of the instinct to escape. That such a stimulus has been at work since animal life first appeared we can hardly doubt. The big have always preyed, and the small have always desired to escape. Obeying this primary desire to remain alive, animals have developed wonderful dodges to circumvent their natural enemies. Into the solid earth they have dug holes and lived out of sight; their bodies and their colouring have been modified to so accord with their surroundings that they were difficult to find; poisonous and nasty juices have been accumulated in their bodies to suggest to those who fed on them that a change of diet would be a good idea, and we might continue the list for many pages.

We can imagine that many a hunted creature echoed the Psalmist's sentiments, and longed for a resting-place in the wide expanses of the air, even if we interpret the longing on a very low level of thought. We can see at some far distant time, some such fleeing animal escaping by a phenomenal jump, aided possibly by some parachute effect of an accidental bodily modification. We need not stay to quarrel as to whether this creature would transmit its peculiarity to its offspring. At least it would have a better chance of transmitting anything than those of its brethren who were devoid of the useful appendage. Possibly its followers developed the idea under similar conditions. Whatever the method may have been, the conquest of the air was made long ago in the history of the world. The common need of finding a refuge stimulated more than one group of animals to essays of flight.

We have fossil remains of a very ancient flyer—the

Pterodactyle. This creature was a reptile, with a fold of skin stretched between the bones of the arm and leg and a very much elongated fifth finger. Numerous varieties of this somewhat clumsy dragon-like animal are known, which vary from the size of a sparrow to animals with eighteen-feet wings.

Still living with us, we have that strange animal the bat, with its fluttering and awkward flight, which is accomplished also by a fold of skin which is attached to the bones of four elongated fingers, the arm, the sides of the body and even the tail. The bat is the only example of a flying mammal, the group of animals that suckle their young. The whole life of a bat is a blundering affair. It cannot fly very well, it cannot move very well unless it flies, it cannot see very well and very slight disturbances of its environment cause its death. So specialised has it become for the particular mode of life which it lives, that we can only expect it to die out in the future.

The creature of the air, *par excellence*, is the bird, which has replaced the extension of the skin by a growth of feathers attached to the bones of the arm and hand, duly modified for this purpose. The birds have attained complete mastery of the air, but have sacrificed, at the same time, that ease of movement on the ground that would assure their safety there. To the ground they have to return for rest and nesting. Possibly the bird is rivalled by the insect, whose wings are an extension of the sides of its outside case. This actually is the skeleton worn, as is the crab's, outside instead of inside. Further than these very proficient aeronauts, we have numerous other animals such as the Flying Lemurs and Flying Squirrels, which are really gliders. They rely on skin extensions to take huge gliding leaps, and a study of their structure leads to the conclusion that each group of animals has devised the gliding apparatus afresh in response to the need, and that nothing is owed to a common ancestor. There are also the Flying Snakes of Borneo, which flatten their bodies and launch themselves into the air. The Flying Frog has widely stretched webbed toes used for support in the air. The Parachuting Spider has plate-like extensions on the sides of its body, and we must not forget our own spiders that launch themselves into the breeze, hanging on the end of a gossamer strip of silk, to "fresh woods and pastures new."

With such a wealth of example around him, it is not surprising that Man turned his attention to flying early in his history. The earliest legends abound with mythical stories of beings capable of flight. We may mention the old carved figures of Egypt fitted with wings; the stories of Icarus, Perseus and Hermes in Greek mythology. The Dragons of the childhood of Man were flying beasts, and the legendary Bladud, King of Britain (852 B.C.), was killed while flying according to later accounts of his exploits.

Possibly the earliest serious contribution to Man's conquest of the air was that made by Roger Bacon (1214–94) who seems to have imagined or described a machine with flapping wings. That extraordinary man Leonardo da Vinci (1452–1519) tackled the subject with enthusiasm. Da Vinci studied the problem in a truly scientific manner. His notes deal with the flight of birds, on which he recorded in 1505 some remarkable observations. Unfortunately he never troubled to publish his work, or subsequent workers might have made much more rapid progress than they did. Da Vinci, for example, says, "A bird is an instrument working according to mathematical law, an instrument which it is within the capacity of man to reproduce with all its movements." To the investigation of these mathematical laws he made valuable contributions. Bresnier, working along the line suggested by da Vinci, constructed a glider with flapping wings that actually achieved a flight. Such happenings produced much excitement especially among speculative writers. Even Addison poured sarcasm on the idea of human flight, on one occasion writing, "It would fill the world with innumerable immoralities, and give such occasion for intrigues as people cannot meet with who have nothing but legs to carry them. You should have a couple of lovers make a midnight assignation upon the top of the monument, and the cupola of St Paul's covered with both sexes like the outside of a pigeon house."

In 1766 Cavendish discovered the gas hydrogen, the lightest known material in the world; and five years later Cavallo filled soap bubbles with this gas and recorded their flight in the air. In 1782 the famous Montgolfier brothers constructed a small paper balloon which rose in the air when filled with hot air. In April 1783 they repeated this experiment, and on June 5th of the same year, at a public demonstration, caused a hot air balloon to ascend some six thousand feet. This balloon had a diameter of about thirty-five feet. In the following September a similar structure was made to raise a carriage containing a sheep, a cock and a duck to a height of 1500 feet and in eight minutes travelled two miles before coming to the ground. These successes attracted immediate attention. Human ascents were made and Professor Charles of Paris employed hydrogen to fill the balloon instead of hot air.

At this time, however, the balloon attracted more attention as a form of amusement than anything else. Such an invention, however, was certain to find a practical application. Its possibilities for transit were foreseen early. Giffard in 1852 constructed a spindle-shaped balloon, which was propelled by a small steam-engine and from that time onwards slow progress was made, until we come to the mighty airships constructed to the design of Count Zeppelin. His work showed that giant dirigibles were practical and during the war their design underwent further improvements. It is of interest to compare the first ascent of human beings in a balloon with the modern luxurious airship.

"*On the* 19*th October* 1783 *M. Pilâtre de Rozier and the Marquis d'Arlandes ascended at Paris in a Montgolfier balloon. . . . It was of oval shape, made of canvas, with the outside painted with the signs of the zodiac. The aperture of the lower part of the balloon had a wicker gallery of sixteen feet internal diameter. A brazier was supported in the centre of the gallery with chains connected with the sides of the balloon. The fire was maintained as required during the ascent by using straw, wood, etc., as fuel. The chief particulars of this balloon were: Diameter* 48 *feet, height* 74 *feet, weight with two passengers about* 1600 *pounds.*"

"*H.M. Airship R*34. *This rigid airship was built by Messrs Beardmore for H.M. Government during the latter part of the war. It was the first lighter-than-air craft to achieve a direct trans-Atlantic flight.*

"*The rigid structure, or framework, in this airship consists of a number of polygons built up of individual duraluminium girders spaced ten metres apart longitudinally, and joined from corner to corner by other lattice girders, the whole being braced with steel wires. The gas-bags, nineteen in number, are enclosed in these frames and are made of fine cotton proofed with a layer of rubber to which is attached a layer of goldbeater's skin. Four cars are suspended from the hull structure. . . . Five Sunbeam-*

Coatelen 'Maori' engines of 275 *horse-power each are fitted.*

"*The principal data are: Overall length,* 640 *feet; diameter* 79 *feet; extreme height,* 92 *feet; capacity,* 1,959,000 *cubic feet; maximum speed* 52 *knots per hour; gross lift,* 59 *tons.*"

Alongside the development of the airship, slow progress was being made with heavier-than-air machines. In 1842 Henson and Stringfellow made a model strangely like a modern monoplane, which however was not a success. Four years later, Stringfellow made another model which actually did fly. Throughout the rest of the century attempts were made to study the problem both practically and theoretically. We may mention Wenham, Lilienthal, Pilcher, Chanute, Ader, Langley and Maxim as names famous for their contributions, both practical and theoretical, during this period. The brothers Wright, after long and careful study, actually accomplished flight in an engine-driven machine, in the early years of the present century. Rapid strides were made about this time with the development of light but highly-powered petrol engines. Most of us can remember the terrific excitement caused by the arrival of an aeroplane from France, having negotiated the English Channel. Twenty-two miles was a marvel of achievement. The science of aeronautics was at this time, however, occupying the attention of the enthusiasts only. There did not seem to be any prospect of commercial application of the new method of transport in flimsy machines none too safe at any time. The science was therefore starved for funds, and its progress severely handicapped. It was not until the days of the War provided a use for the aeroplane that the rate of progress improved. Then the study of design was gone into deeply, and the very difficult dynamics of flight tackled by our foremost mathematicians. From a scientific toy the aeroplane became an all-important arm of defence and attack, and to-day can be said to be as stable as the taxi-cab. We may quote the recent demonstration flight of Mr Alan Cobham.

"In a two-seater Biplane—a D.H. Moth—fitted with a 27–60 h.p. Cirrus air-cooled engine, Mr Cobham flew from London to Zurich and back in 13 hours 51 minutes. His average speed was 71 miles per hour and his average running costs for the whole journey worked out at about one penny per mile. This may be compared with a similar journey by train and boat, which, at the best possible, would take 37 hours for the return journey and cost £11. 6s. 3d. It has been estimated that a powerful touring car would take sixty hours—excluding the channel crossing—to accomplish the journey, at a fuel cost of £6."

The Wright machine on which the first human flight was accomplished had main planes 40 feet long and 6.5 feet wide. It had a total supporting area of 500 square feet and the total weight of the machine was 800 pounds. It was driven by a water-cooled engine weighing 200 pounds and developing 24 horse-power. Again let us compare this with the first heavier-than-air machine to accomplish the trans-Atlantic flight. This was accomplished on the 14th–15th June 1919, in 15 hours 57 minutes at an average speed of 118.5 miles per hour, in a Vickers-Vimy Rolls-Royce machine. The span of the main planes was 68 feet. It carried 865 gallons of petrol, and when loaded for its flight across the Atlantic it weighed nearly six tons. It was fitted with two 360 h.p. engines, each driving a four-bladed tractor air-screw. Such a machine would have a range of over two thousand miles with a maximum speed of 120 miles per hour.

Considering that such progress was made between 1903 and 1919 we may confidently look to the future for further progress that will make the imaginative novelist's task a very difficult one. We may not yet be able to rival the birds and bats as to safety and ease of movement but at least we can score over them in another direction, and it is this aspect of the flight of Man with which we are mostly concerned here. The Pterodactyle is long extinct, the bat is so structurally modified to fit it for its clumsy flight, as to suggest its speedy extinction, the bird is master of the air but more or less helpess on the ground. The other so-called flying animals are not serious competitors for the supremacy of the atmosphere. Man alone is slowly gaining control of this domain with his machines made of wood and steel. Vast muscles, to support which the bird and the bat have had to undergo structural modification of bone, are replaced by man by the petrol engine. Science is providing him with a new organ of locomotion, and yet leaving him the original freedom of bodily form which is at once his most treasured possession and most powerful weapon for the attack on the future.

This organ of locomotion is one which is likely to have a very great effect upon the future history of the whole human race. Facility of travel, we have seen, means more and more intercourse with other members of the race, and the breaking down of the artificial boundaries erected by misunderstanding. The steamship and the railway have done much towards uniting the civilised world into an harmonious whole. The aeroplane will do more, for less than either the steamer and the locomotive is it affected by the geographical boundaries of the world. The aeroplane can cross the mountains and the oceans with equal facility, and the extensions, that we can see dimly in the future, will spell the destruction of those narrow prejudices which often pass as national aspirations.

CHAPTER XV

THE CHEMISTS' TRIUMPH

" *All that glitters is not gold.*"

FROM cosmic theories of the origin of the solar system, from the intricacy of the tiny atom, from the majesty of the story of Man to silk stockings is somewhat of a jump. Yet the silk stocking, or rather the very much discussed artificial silk stocking, is a useful illustration of one of the contributions of Man's mind, through the channels of science, to the welfare of the human race.

Let us look at this silk question a little more closely. It may be argued that silk is in no way a necessity of life. That the world would be just as happy without it, and that the scientists could be better employed than dabbling with the fripperies of modern fashion. Such contentions however ring very untrue when we consider the question more deeply. The Venus de Milo, the landscapes of Turner and the poetry of Shakespeare are also not necessities in this sense, but the world would be poorer without them, for it is still true that man cannot live by bread alone, or to modernise this truism, the fullest life cannot be gained by wonders in brick and metal alone. Man has a mind, and the highest stages of evolution need the occupation of that mind in all its aspects and of these the æsthetic is by no means the least. In so far as silk ministers to the comfort of humanity, in so far as it enters into the artistic productions of Man, it is a necessity.

This beautiful product, which anyhow we all admire, was developed naturally for a very utilitarian use—to provide a web for the spider, and give the insect larva a weatherproof cocoon in which to spend the resting or pupal stage of its existence. Man delving into Nature to find what was good in his sight, selected the poor little silkworm and sacrificed millions for the production of his silken robes. The production of the natural product is, however, attended with certain risks. The animal may suffer from disease, and so seriously injure the product. It is also dependent in its early life on very precise and definite food supplies, and thus the area in which it can be raised is both limited and defined. The artificial product of Man can be produced anywhere and there are no attendant disadvantages such as diseases. At the present time it must be admitted that the artificial product does not equal that provided by nature, but this particular industry is still very young and we may expect in the future a product that will equal the natural silk in every respect.

Silk is not the only product that Man has claimed as a tribute from Nature. He stole the colour from the Madder and the Indigo plant, squashed the octopus to get his Royal purples, dipped his robes of silk in the products, and walked the world in all the glories of the flaming sunset. He distilled the juices of the grape and enriched the vintages of Nature, he put the ox into a bottle, he tanned the skins of his captures to make leather, and in many another product has demonstrated that peculiarity of Man which expresses itself in a definite examination of his environment.

While considering these triumphs we see the truth very clearly of the fact that "a man may not find what he is looking for, but he never finds anything unless he is looking for something." Let us take one striking example. In 1816 the English chemist, Sir Humphry

Davy, while searching the raw material of the world for new elements, found the existence of those rare elements which the chemist groups together as the "elements of the rare Earths." These occur in very small proportions in certain rocks and seemed of very little importance. In 1829 Berzelius observed that the oxides of these elements gave a very bright light when heated in a non-luminous flame. Very small beginnings these, but in our own time compounds of these rare elements form the basis of the incandescent mantle industry. The Welsbach mantle was patented in 1893 after years of careful research. It consists of a mixture of thorium and cerium oxide, products obtained mainly from a deposit of monazite sand that is found in Carolina and on the coasts of Brazil. The material of the mantle is impregnated with these products and manufactured to the enormous quantity of some sixty millions a year for the British Isles alone. We may also instance the foundation of the mighty industry which provides the dyes of the world. The first artificial dye was made in London in 1856 and resulted from work that was being done in quite another direction. From this accidental discovery has grown up the enormous trade that has revolutionised our processes of dyeing.

In this last connection it will be convenient to examine the contention that the work of Man is an improvement on that of Nature. Natural products, in that they are produced by living agencies, have that characteristic of life which is expressed by eternal variation. The robe that gave one hue in a particular vat of dye, came out another shade in the next which apparently was identical with the former one. There was no surety in the use of vegetable dyes. It was, as we say, more or less a matter of luck as to what result was obtained. In primitive societies such luck would not matter very much, but with the extension of civilisation and the growth of trade greater certainty would be demanded. The mind of Man has a habit of meeting the demands made upon it even if the process consists of seizing upon the first favourable opportunity to do so. Centuries had to pass before this favourable opportunity arose, and Perkin made the first artificial dye. Now the dye-works can turn out any brand of dye that is required, and guarantee that every sample will act just as other samples did. Constancy has been achieved and the dyer can go ahead with his tasks without any doubt as to the quality of the finished product. Further than this, the artificial products cover a much wider range of colours than is found in nature.

In this sense we may consider the work of Man an improvement upon that of Nature, although it is really straining the meaning of words to call the products of Man's work artificial. After all, Man is as natural as all the rest of creation and what he does is also natural. It is better to keep to the scientific word "synthetic" for these products. This implies that they are prepared from simpler materials, are indeed manufactured and not obtained ready-made from any natural source. We have mentioned only a few of these contributions to a fascinating aspect of human activity. The list could be extended *ad lib.* We may mention the great benefits that have accrued by the turning of the natural substance cellulose into paper. The substance cellulose appears widely spread in nature, forming the cell-walls of plants and animals. A thousand uses have been found for it, of which the making of paper is possibly the most striking. A big daily paper will use up the equivalent of some two thousand acres of forest a year and it has been truly said that "the utilisation of cellulose is the chief cause of the difference between the modern and the ancient world." Collodion, celluloid, perfumes, soaps, drugs and all the products of coal-tar distillation may also be mentioned. Synthetic rubber is well on the way towards commercial perfection, and in the future will compete with the natural product. Synthetic alcohol, for use as a fuel, has been made on a commercial scale and will have a great effect in the future.

The synthetic chemist has no doubt that further research will give him increased knowledge, leading to the synthesis of a vast number of other substances in daily use. The purity of synthetic substances is assured and from a commercial point of view they can compete with the products obtained naturally. We can see the clucking hen replaced by a row of test tubes and the careful housewife getting her grocery supplies from the chemist's shop!

We need not stay to dream of the future, but we may usefully inquire what the outcome of this artificial activity of Man has on his history. Purity of food products will make for health. Purity of products of commerce will make for the stability of trade. That the synthetic product is independent of time and place is an advantage for civilisation. There is no waiting for the proper season to gather the fruits of the harvest. The element of uncertainty is being removed, which is all to the good, and the chemist is giving the world a wider range of products and making the privilege of the few the possession of the many.

Again, each conquest means another stage in the exploration of the Universe, and the more we understand the further we can advance. Again, for good or evil mankind has set out on a path that leads to his gathering in communities. In such congested areas it is impossible for the neighbouring ground to supply his wants. The chemical works in the big city represents many acres of land in the country, and thus makes this community life possible on a wider basis than it would otherwise be able to take place.

CHAPTER XVI

THE MIND OF MAN

" *Mind is ever the ruler of the Universe.*" PLATO.

" WHAT I do not know about my own mind, no one else can tell me " is the secret conviction of most of us. Our material bodies we cannot hide, but our minds seem to be the real " us," the supreme commanders of all that is possible to us, and they are locked up inside us. This is really a very comforting thought, and to it we often add the boast that " supreme is the dominion of mind over matter." Still our comfort and our confidence suffer some very rude shocks in the hurly-burly of life. Times arise when, as we say, we " lose our heads " and find ourselves embarked on courses of action of which our minds neither approve or control. Or we find that we have arrived at a certain position by the quiet influence of mental activities which, at the time, we never even recognised, and we doubt the supreme control.

Then we watch our fellows and we see this one with a face wreathed in smiles and understand perfectly the mental state that the smiles suggest. Again, we recognise that another is passing through a mental experience that we also had, and we can follow the steps quite clearly. What we really do is to interpret the bodily actions in terms of mind, and some of us are very clever at this " thought reading." All of which leads us to doubt the secrecy of our own minds.

If we settle down to worry out the matter, we soon appreciate the fundamental fact that, though to a certain extent we may be masters of our fates, there is some mental drive or power behind our lives over which we have very little control. In fact we hardly notice its existence unless we direct attention to it specially. We find, if we push our inquiry further afield, that what is true for ourselves also applies to humanity in bulk. The problem reduces itself to the finding of an explanation of the behaviour of man, and dimly we recognise that this explanation must be a mental one. The body is but the instrument of the mind and without it our frames would be mere inert bulks of matter. History shows us centuries of struggle, yielding much that is good in which we can recognise progress, yet the world's problems to-day are immense and in our most advanced civilisations there is much that is evil. Somehow we feel that this could be altered, if only we knew what the laws of behaviour were. Our mistakes may only be the ignorant breaking of these laws, and so we see a world, weary of wars and rumours of wars, seeking insistently of the psychologist the why and the wherefore of life.

Psychology—the science of Mind—is the infant among the sciences, only just out of its cradle. Its period of infancy has been abnormally long and extraordinarily barren of any useful contribution to the needs of humanity. Up till about the last half century, psychology was but a branch of philosophy, in which school it could only deal with intellect and reason, for nothing else is recognised there as of any importance. The philosopher studied the mind by a process of classification of those two aspects of it, and a very good classification he produced, but one which was strictly academic and as far removed from mundane things as possible.

During the next twenty-five years two other aspects of psychology sprang into prominence. In the field of education psychology tried to find a practical application. It was a nice peaceful field in which the sun of intellect shed rays of reason on a stunted and vegetative growth. The abstract views of the philosopher merely served to increase the intensity of the rays and the crop withered under the scorching fire. Educational psychology became a course which the teacher took at college but wisely left outside the classroom. At the same time an eager band of enthusiasts made laudable efforts to introduce scientific methods into the study of mind, by a process of measuring everything and anything that could in any way be associated with mental activity. Again intellect and reason offered themselves as the best fields for this work, and the philosophical foundations were strengthened. These attempts at practical and experimental work served a very useful purpose. They showed clearly that the older psychology failed utterly as an explanation of the behaviour of Man. A thorough reconstruction of the subject was necessary and the recognition of this necessity marked the stage when the baby science began to toddle. Since those days we have made much progress, and although no one imagines that at present we have made more than a favourable start, we can at least feel that the old era of stagnation is over and that at last we are moving along the right road.

During the past twenty-five years we can detect a complete change of outlook on matters psychological, and to a large extent this is due to the very much delayed recognition that man and the other animals are not distinct manifestation in this world. The unity of life and its gradual evolution from simple beginnings has been found to be applicable to the mind as to the body. We have been looking for simple manifestations of mental processes in the lower animals, and have found them. In the simple we have been able to perform useful analytical processes, and with what we might call the mental units so obtained we have been able to build up towards that much more complex structure the mind of Man. The structure as we see it now is admittedly a tentative one, neither complete nor accurate in all its details, but by general agreement the main outlines are considered to be correct.

Let us look into the problem a little more deeply. We are setting out to explain behaviour, which we might define as the reaction of the organism to its environment. The crystal, as far as we know, sits passively where it is formed. Given suitable conditions it will increase in size or grow along very definite lines; given other conditions it continues to sit still. The living organism, on the other hand, will make strenuous attempts to overcome adverse conditions. It will try this way and that to attain its various needs, and in fact, if it fails, it dies and ceases to exist as such. The hungry dog given its meal in a closed box, will endeavour to open the box and will succeed, if the opening is within its manipulative ability. Further than that, with repetition of the same problem, the dog will improve on its first blind efforts, it will learn by experience the best and quickest way of getting that food out of the box. We say, and say truly, that the dog exhibits intelligence. If we extend the inquiry we find that in every walk of life similar intelligent behaviour can be detected. Some of it, of course, is at a very low level. We should never expect the worm, for example, to learn how to open a box, but in other respects the worm, and other much more lowly creatures, can be shown to exhibit this very distinctive feature of intelligence which reaches its highest manifestation in Man.

We are tempted to ask why should the dog trouble to open the box, and the answer, "Because he is hungry and needed the meal," does not entirely satisfy. The dog may have learnt from past experience that a meal will satisfy that craving which we call hunger, but that could not possibly apply to a new-born puppy, which in its struggles for a place at the living restaurant provided by his mother, goes through more much complicated actions than those required to open a box. What urges the puppy to seek food at all? He cannot have had time to have learned any such process, and so obviously it must be some inherited tendency. It is a tendency that urges the little creature, with no experience at all, to go through all the complicated actions of sucking. It is an urge that will not be denied. He fights to obey it, struggling with his brothers and sisters, and, if you obstruct him, he puts forth every effort of which he is capable to perform this normal function. There is no question here of thought, of intellect, or reason; it is a blind urge leading to a perfect set of mechanical actions, which when completed satisfy the urge. Such inherited tendencies we call *instincts*.

Few words in the English language are responsible for more misunderstandings than the word "instinct." At times it seems almost as if it were used as a label for anything that is not understood. If we fail to see why such and such behaviour occurs then we label it instinctive. This would not matter very much as long as we recognised that it did really mean ignorance, but giving a name is too often made to have the significance of giving an explanation. The word instinct, however, has now a precise scientific meaning which we will attempt to make clear. In the animal world we recognise many instincts. We need enumerate only a few for our present purpose. There is the instinct of danger which urges us to escape; the parental instinct which drives us to protect the loved ones, especially our offspring; the pairing instinct, that impels us to seek a mate; the food-seeking instinct under the impetus of which we seek food; the gregarious instinct which causes us to seek the company of our fellows.

As we think over these instincts we see that there are certain peculiarities about them which we can stress. In the first place they are inherited tendencies, they do not have to be acquired. They are either present fully developed at birth or they mature at appropriate times later in the life of the individual, independent of all the forces of education in its widest sense. Possibly they are the inheritance of ancestral experience, but be that as it may, they are part and parcel of the make-up of every animal.

Next we notice that every instinct is accompanied by a definite and appropriate set of bodily actions. There is *something* that the animal always does in response to the instinctive impulse. The new-born baby performs the actions of sucking in response to the impulse to seek food. We see that such an accompaniment is necessary for the safety of the individual and of the race. No baby would live long enough to be taught how to obtain food. Then we have to admit that the instinctive impulses arise on their own. We do not say, "Now I am hungry, I will get a meal," or, "Now I am frightened, I will run away." On the contrary, we just realise that we are hungry and make for the nearest food supply, something frightens us and we run away almost before we know what we are doing. It is an effort, in fact, to resist the impulse and it is doubtful if the lower animals ever do attempt to do so. The dog feels hungry and at once proceeds to eat the biscuits in its tray. It is a task requiring much patience to teach him to restrain the natural outcome of his instinct at the command "Trust."

This leads us to the realisation that there is usually some particular set of circumstances that start off the instinctive impulses. A peculiar feeling in our insides produces the hungry urge. Something unknown causes fear and we run away. We can make a list of all the known instincts and put opposite them the conditions or objects which excite them. The instincts have a specific stimulus, and nothing else will arouse them. Thus we never desire to protect the pebbles on the beach from the fury of the waves, but our own child in similar danger calls forth the parental instinct and we rush to save her from harm. Once the instinct has been aroused the whole animal comes under its influence. We experience an emotional state which is appropriate to the instinct. When we are frightened we experience the emotion of fear, when urged to seek food we feel an emotional craving within us. We shall see later that these emotions are capable of very important developments.

Such then are the instincts, inherited tendencies, innate dispositions to react to certain definite stimuli, in certain definite ways, giving rise at the same time to certain definite emotions. Of recent years much work has been done on the instincts. We find them in all animals, including Man. They are the raw materials of mental structure with which the animal starts life. Careful examination of our own behaviour will reveal the operation of the instincts from the earliest times we can remember. Such an examination will also reveal the fact that as mature individuals we have very much modified many of the bodily actions that accompany the instinct. We no longer blindly follow the impulse and grab the nearest food at the dictates of hunger. We have learned to possess our souls in patience, and have a decently prepared meal. Only exceptionally do we run from danger. We have learned to control the impulse, face the danger and act in accordance with our social tradition, a tradition of honour and courage that has grown up under conditions where immediate flight was not essential for the bodily safety or material welfare of the individual. Nevertheless we feel the impulse as of old, but reason has come to aid it and control it. We have also improved on the early bodily actions of childhood. We no longer suck our nourishment from a bottle, or tear our food to pieces with our teeth. The etiquette of the table has provided a more efficient set of actions suited to our present state. Reason may step in and dictate that a blind rush into the water to save a child, when we cannot swim, is folly, and direct our attention to a boat as a safer and saner method. Anyway we obey the same impulse and reach the same end.

Along similar lines of thought and experiment much very brilliant work has been done in recent years. The War stripped millions of men of the conventions of civilisation, and showed the primitive instincts working in them more clearly. The medical profession have made considerable contributions by close study of mental diseases, where a morbid condition often gives prominence to one or more instincts. Comparative studies of many different species of animals have been of great help. So firm are the foundations of this work that the theory of behaviour which has grown out of it commands very great respect. This theory we may sum up in the words of Prof. McDougall, its greatest exponent. He contends that "in every case the motive (of activity) when truly assigned will be found to be some instinctive impulse or some conjunction of two or more impulses," and again, "the instincts are the prime movers of all human activity . . . the instinctive impulses determine the ends of all activity and supply the driving power by which all mental activities are sustained. . . . These impulses are the mental forces that maintain and shape all the life of individuals and societies, and in them we are confronted with the central mystery of life and mind and will."

To do justice to the author quoted, it is necessary to read the above dogmatic statements in conjunction with his statement that his "conclusions are only working hypotheses, which may be far more wrong than right and which at the best are only crude foundations for psychology." McDougall has spent thirty strenuous years formulating and working on the details of this theory, which the more we think about it the more we are convinced of its sound common sense, in its essential features. Confirmation of its tenets is coming from all sides. It is instructive to inquire what other motives for mental activity have been suggested and which we can use if we reject McDougall's *Hormic Theory*. There is the mechanical theory in existence, which makes all human action of the nature of a reflex action, a mere matter of nerves, stimulated by some external agency. According to this we become mere creatures of circumstance. Then we have the remnant from philosophy, which imagines that all action is directed towards attaining the greatest amount of pleasure and the least amount of pain. For actual pleasure and pain, later exponents substitute an "idea" of these two qualities. This theory totally fails to explain those actions which make directly for pain and which are so common in the little actions of life. There is also a theory of ideas which supposes that something called an idea, not too clearly defined, in some unexplained way is the motive force of action. The Will, whatever that may be, Reason and the Unconscious have likewise been given the power of controlling, or rather being the motive power, of all action. We cannot help but come to the conclusion that the majority of the exponents of these views are using words which have no very precise meaning and letting them cover a multitude of sins.

The simple fact remains that we can each of us recognise these instinctive impulses at work within us, and see that they do compel us to action. In company with our fellow-men we are modifying their application so as to best fit them for social intercourse and the progress of the race. This modification consists in the enlarging of the content of the emotions that accompany the impulses. We let the feeling of protection, specific to the parental instinct, extend from the immediate loved one to a wider field of suffering humanity. On such an extension is based all that is meant by social reform, all the work of philanthropy. We may not be prepared to give to these innate dispositions the whole and sole control of all human behaviour. We may prefer to reserve an open space for some yet undiscovered factor, but at least it seems impossible to doubt the fundamental part which they play in our lives. It may not be gratifying to our pride to realise that the mainspring of our actions is the same as that of a worm or any other creepy-crawly creature, but, after all, the superiority of the human race must be based on something more solid than pride, if its history is to have anything but an ephemeral career. On this point we can draw a distinction between the higher and the lower animals. The instincts of man are much less specialised than those which we observe in such animals as the insects. There we have instincts which lead to the most complicated actions, such as the construction of social habitations by wasps, bees and ants. For the life that these animals live they are admirably fitted with appropriate instincts, but it is easily seen that very slight modifications of conditions would result in their entire extinction. They are too specialised to adapt themselves. The instincts of man, on the other hand, are less specialised than in any other animal that we know. They possess immense capabilities for modification of their line of action, and are thus factors for progress in the race. We can not only glory in the adaptability of our bodies, but we may see a similar feature in our mental structure.

We must also refer to another recent contribution to the study of mind, which has attracted considerable attention. This work was initiated by the German psychologist Freud who investigated what is called the Unconscious. The history of any individual mind is the story of innumerable experiences. The present consists of experiences of which we say we are conscious, and the moment we turn our attention to this consciousness or awareness we see that it is a very complicated thing. It is a something for which we have no very suitable vocabulary to describe, and in the use of ordinary language we may easily fall into error, by implying a meaning which we do not intend.

Our examination of our own consciousness leads to the conclusion that there is a " position " in it which is very vivid, the " centre " of our immediate attention. " Beyond " this there is an " area " in which a number of things seem to be hanging around—just not at the vivid point. As we read, for example, the centre of attention is the thought that the book provokes, but also hanging round are the thoughts that led up to the present one, a vague anticipation of what is coming, a still vaguer appreciation of our own bodily comfort, the noises in the air, the lighting, other people in the room, and so on. At any moment any one of these might become the centre. Then more " distant " still are other portions of consciousness, such as memories of past holidays, anticipation of future appointments. These we can "recall at will." If we settle down and think carefully, we know that we can recall large portions of our past experiences. But also there are experiences which we have entirely forgotten, not temporarily, but entirely; and no effort of ours will bring these experiences once more into our minds. They have, as we say, gone for ever. On certain periods of our life our minds are a complete blank. It is convenient to give to these past experiences, that have been forgotten in this way, the name Unconscious. Freud set out to examine this unconscious "area" of the mind. He emphasised the existence of the unconscious and he carefully examined all possible methods by which these hidden experiences could be dragged up into consciousness. Under the influence of hypnotic suggestion it is possible to make a subject recall forgotten experiences. Psycho-analysis, of which we have all heard so much, is another, and it is a very dangerous method in the hands of anyone but a trained expert. It cannot be too often stated that it is simply asking for trouble to dabble in this debated area of scientific inquiry. Irreparable harm may be done by the amateur. This is no denial that, in proper hands, the methods of psycho-analysis are a valuable means of exploring the unconsciousness. So far, every psychologist owes a debt of gratitude to Freud, but the debt is likely to be forgotten amid the vapourings of his so-called followers.

Freud showed that our mentality was of such a nature that under certain circumstances an experience could be forced into the unconscious, and so lost for ever, until some special means were taken to revive it. He showed that unpleasant experiences were likely to undergo this process, and at the same time they would take with them any other experiences connected in any way with them, thus producing a hiatus in the story of experiences of any life. This, which we might almost call the science of forgetting, was a most valuable contribution to the study of the mechanism of the mind. Freud, however, went a step further. His work led him to suppose that these lost elements in the unconscious had a very marked effect on the conscious. In some way they were considered to tinge the whole of mental activity. Freud and his school dug diligently in this hidden tract of many patients, and their work led them to the conclusion that much of the contents of the unconscious were in direct relation with the powerful influence which we have called the mating or pairing instinct. This side of the unconscious was overemphasised, and later pupils of the school have made the unconscious a mass of lost sexual experience of a none too pleasant kind. Further, to these lost factors they have given the sole control of mental life. It is no exaggeration to describe the structure which they have built as an absurdity. Still the whole subject cannot be dismissed under this heading, but on the contrary is worthy of very serious attention. We may see something akin to the unconsciousness in the instincts, for they seem to be based on some former racial experience, and of their existence in our own mind we have no other evidence than the actions to which they prompt us. They appear to "well up" from beneath, providing mental energy and pointing the direction in which it should act. Possibly the instincts dwell in that debatable area, the unconscious.

The present position is that we recognise the existence of the unconscious as defined above. We admit that in some unexplained way it may influence our mental structure, but to what extent this influence occurs we are wise not to commit ourselves in any way. Further, we recognise that the instincts provide a motive for almost all our actions, and that to a certain extent they are under our control. Admittedly such a position is only a beginning but it is a foundation on which we may erect the complete building, and feel that at least we are safely resting on rock and not shifting sand.

CHAPTER XVII

THE CROWD

"*We all in fact demand an aim, a human aim; what else is existence but an end with the means calculated to attain it.*" MAZZINI.

WE are nearing the end of our story and perhaps it would be as well to gather up some of the tangled ends. We have seen something of the structure of the globe on which we live, in the history of its crust and the complexity of the tiny atoms of which it is composed. Matter we have seen to be composed of little bits of electricity and to be associated with that all-important quality we call force. Dimly we have glanced at the ways in which science is viewing the material Universe. Still more dimly we have glimpsed at a possible development from dead matter to the living organism and seen the possibilities of further progress along evolutionary lines. Through the ages we have seen the simple become the complex, such complexity, at least on the main stem of progress, being more a matter of potentialities than of structural modifications. Finally, we have reached the keystone of the arch of life in the mind of Man.

Throughout we have endeavoured to stress two main contentions. In the first place we have indicated that specialisation spells destruction, and then that the task of science has been to supply the needs of the specialist and yet leave the individual free for further development as needs demand it. To these contentions has been added a claim, that of all the animal creation Man, in bodily and mental structure, represents the tip of the main stem of evolution. From every angle of consideration he is the most plastic thing alive, more closely related to the primitive than any of the higher animals, more capable of future progress than any other form of life. This is a doctrine of optimism, but it is hoped that it has also been made clear that it is potentialities that Man possesses. They should be treasured inheritances, but they may be thrown away, wasted by not being used properly, or spent on fruitless journeys into the land of specialisation.

We often say that we live in an age of specialisation, where each of us follows a narrow path and knows little of what is happening in fields other than our own. To a certain extent only is this true. We have to recognise that Man's exploration of the Universe is comparatively only in its early stages. As with any exploration work, the early journeys give but a fragmentary picture of the new country. It is not until the bands of workers get back to headquarters, and compare their achievements, that broad views become possible. We are still very far from that complete picture towards which scientific inquiry is leading, but at least we are in a position to judge of the main structure. We can, as it were, map out the valleys of hypothesis and the ridges of theory. Here and there we can name the peaks of fact and track some of the rivers of conjecture down to the ocean of knowledge.

That portion of this map which concerns the human race is of principal interest for us, although we recognise that to isolate Man as a special product of the world, a thing apart, only leads to false conclusions. Matter, the inorganic basis, Man, as typical of life, and Mind the controller of both, must be welded into one scheme. Yet the student of Matter, Man and Mind may be likened to a very short-sighted person, provided with a magnifying glass, and set to study the back of a large tapestry. From the blurred colours, the tangled and cut ends that he sees, bit by bit, he is expected not only to describe the picture on the other side, but also to explain the interpretation of it in the mind of the original designer, and the methods adopted by those who worked on the pattern.

Still we demand from those who delve in these regions of inquiry some explanation, and believe that all these investigations of the past, and examinations of the present, should give us the key to the future. The appeal to history has often been very much overdone, for it is never possible to repeat the conditions of one age in a later one. The correct appeal is to the analysis of the past and present, so that we may obtain the units of which the modern complex structure has been made. That some structural alterations are necessary we all assume. "God's in his heaven, all's well with the world," is not a doctrine of passivity, but of feverish activity, for of a certainty the world to-day is not a replica of any heaven. It is stupid folly to attempt any reconstruction, if we do not know of what the bricks are made or how they are arranged. Our attempts in such ignorance are more likely to bring the whole structure down on our heads than to strengthen it and improve it. We have seen how an analysis of the past and a comparative study of the present, has led to the discovery of units of mental structure, the instincts, that provide a motive for Men's actions. We have applied them to the individual and if our problem were confined to individuals alone it would be easy to solve it. If we could isolate an individual and circumscribe his environment, it would almost be possible to forecast his life-history; more, we could so adapt the environment as to ensure that he would achieve the best of which he is capable. Modern civilisation does not, however, solely concern the individual. The unit is more the crowd than the individual, the crowd or nation being made up of individuals united for some common purpose. Such combination, concerning as it does so much variety, and existing in an ever-changing environment, makes the problem more intricate. It becomes ever more difficult to analyse what does happen, into the units of which it is composed. Wherever we look there is doubt, doubt as to what is the best step to take for the future welfare of mankind.

From this there arises the necessity of a study of the past history of the race, for, as to-day we find the University professor moved by the same instinctive impulses that drove the ancient Crô-Magnon men along the path of life, so may we hope to find in primitive societies the units from which our modern structure has been built. These influences, which first gathered the individual into tribes and nations, will be found to be the basis of modern civilisation. That in the course of ages these influences will have been modified, extended and made richer in tradition we cannot doubt; but a knowledge of their simple beginnings should contribute valuable assistance to the present. This study is the province of that infant science Anthropology, and the need for it has been recognised for some time; but unfortunately the baby has suffered badly at the hands of well-intentioned, keen but amateur nurses. The raw materials of anthropology are the stray records of extinct races, and the lives of primitive folk alive to-day. The former is obviously the domain of specially trained observers, but to the latter every traveller considers that he can supply material evidence. Even the tourist, back from "seven days in Italy," feels competent to pass opinions on the Italian nation and the sojourner among mere "natives" think that he understands their simple lives from A to Z. Experience, however, has shown that only the work of skilled observers is of any value. It is so easy to be misled by difficulties of language, and the projection into other cultures of ideas entirely foreign to them. Of the observations on which sound conclusions can be founded there is all too little.

The early work in this field, performed with a seeming accuracy, gave a picture of primitive life that is very firmly fixed not only in popular imagination, but in scientific thought also. According to this view we have first the promiscuous mixing of individuals, out of which grew the family. At the family stage the unit of association was the group governed by the "old man," who ruled by the weight of his fist or his skill with weapons. His wives, his children and his captives obeyed his word as law, until such time as arose another, stronger or more skilful, and wrested the leadership from him. Thus was imagined a world peopled with families, naturally antagonistic, roaming hither and thither and collecting that which seemed good to them. The discovery of the arts of agriculture anchored the family, enabled it to collect personal belongings and expand in size. The quieter and safer existence thus provided enabled the member of the family who desired to strike out on his own to settle down by the side of the patriarch and so enrich the community. Thus it was supposed the tribe grew up, and in time became the nation.

There is a sweet simplicity about this scheme, which, however, further work has not tended to support. Certainly we shall find no very safe ground of agreement as to the early efforts of Man at combination, but that a system of warring units ever existed is very doubtful. Such a state is almost a necessary corollary of the patristic theory. It is also doubtful if the father of the family has exerted the influence credited to him in this state. There are primitive races now where the husband holds a very minor place in the scheme of events. It is a mistake to imagine Man as naturally a warring animal, or that war is an inherent attribute of the scheme of nature. Civilisation has not set itself an impossible task in its attempts to eradicate strife. A picture that paints a "golden age" is probably nearer the truth. Man is a hunter, and a fisher. The pugnacious instinct is really rather a noble one, for it is aroused by a desire to protect those we love, and later the sentiment of protection is widened to include the helpless and those in trouble. War we may attribute to the extension of trade, and the activities of uncontrolled greed—the acquisitive instinct in a morbid condition.

Much of this is but speculation, and modern research in anthropology is teaching us a wise caution. Possibly, we originally approached the subject with the preconceived idea of the exalted position of the family, which in our past philosophy may occupy a position to which it is not entitled. The true function of the family is to place the young in their correct position in the society. It is the training ground in which the child learns, without any disastrous mistakes, to accommodate its actions to the customs of the community. When, as at the present, we are faced with huge problems of social reconstruction, it is very important that we should retain an open mind on the subject of the early history of civilisation, and await the safe conclusions that will be based on further rigid investigations.

Similar considerations prevail when we consider the laws and customs of Mankind. The usual picture presented of primitive races, is of a savage hide-bound by taboos and tribal customs and mildly agreeing to courses of action which, to put it mildly, are very unpleasant at times. Certainly we find the taboos and customs in existence but the agreement is not so mild as might appear. At least we are beginning to realise that where obedience is yielded it is not at the mere dictates of fear. There may be some rules and regulations that have behind them the sanction and mystery of the accepted religion, and these, men may fear to break. On the whole we are inclined to believe that obedience to law and order is never given unless the laws are reasonable and appreciated as such by the individual. Men do not fear to break the laws of the land, they may fear being found out, and adopt very cute measures to escape detection. Temporarily *force majeure* may dragoon a community into seeming docility, but sooner or later the forces of reason and common sense will prevail, even if they work slowly by the ways of constitutional reform, and bloody revolution does not break out. It is possible that the future will reveal the fact that all these customs have been reached by a method of trial and error, in which Man has tested first one method and then another till he has found that best suited for the growing community, and recognised as such by all. It is then still possible that some of these customs may outlive their value and be continued, more or less as a farce, as a tribal tradition.

As we review this study of civilisation we see an instance of a very common tendency in scientific procedure. The first examination of a problem usually results in the offering of a very simple explanation, which, as far as it goes, suffices for the needs of the moment. Often it is the explanation of a preconceived idea, or it may have implications that fit in nicely with an existing desire and so be used by the propagandist for the furtherance of his own ends. Further, serious work makes complicated what was apparently simple, and finally we arrive at the common-sense explanation and wonder why we never thought of it before. So now, the simple explanations of the early anthropologist are challenged. The late W. H. R. Rivers, who gave such careful consideration to these matters, voices the protest in the words: "The existing institutions of mankind are not the result of a simple process of evolution, but there has been in action a highly complicated process of blending and interaction of cultures, often widely different from one another, the outcome of the interaction being complex structures, not only containing elements derived from both blends of culture, but also new products of the interaction."

Whatever our final conclusions may be, all this emphasises the importance that we must attach to the study of the community as a whole. This subject is attracting an ever-widening field of workers. The psychologist has joined the anthropologist and together they are making rapid strides towards a better understanding of the problem. A human society acts to a certain extent as an organism. "Just as by the association and activities of its component cells, the human body makes for itself organs of various kinds for the fulfilment of diverse functions, so a human society makes for itself, by the co-ordinated activities of its members, organs that are used by the whole community. A railway train or an aeroplane is no less an organ of locomotion than an arm or a wing; a drainage system is an organ of excretion; a telescope is an organ of vision and a telegraphic or telephonic apparatus is nothing more or less than a nervous system shared by the whole community." When we leave the physical side of the community and think of the mental we see a similar close relationship. The efficiency of the human body depends upon the ready co-operation of the brain and the muscles. If the hand defy the mind then chaos would result. Ideally, the Government of the nation should correspond to the mind, but we must not push this analogy too far, for the units of the community are not mere flesh and blood but individuals possessed of reason and desire. Neither must we fall into the error of inventing some mythical "herd instinct" and making it explain any and every doubt that arises.

Nevertheless, as we consider the subject, we do seem to recognise what we might term the "community mind." We speak of the character of a nation, of national aims and inspirations, and of national movements. We ourselves feel the atmosphere of the nation of which we are units, and grant that it tinges all we do or think. We approach life from a different point of view than other nationalities, and somehow it is difficult to see how this is a personal and not a national thing. We may call it convention, custom or tradition, but, whatever we call it, we appreciate the important part that it plays in life. This community mind seems so real at times, that we can easily agree with one of our foremost biologists in the statement that "the bonds by which the solidarity of a human society is secured are mental and moral, rather than chemical, physical or even physiological."

This mental and moral binding acts in certain senses as a very definite group mind or spirit. It reacts upon all the individuals that live within its influence, and each of us makes a contribution to the sum total, which is certainly not just the arithmetical sum of these contributions. It has a wider significance than this, for it stores the traditions of past ages and we cannot deny that the usual processes of evolution and progress may operate upon it, eliminating what is harmful and enriching by wide combinations that which is good. We are not attempting to delineate anything in the nature of a universal mind stuff of which the mind of the individual is but a point or knot.

Our safest plan with the evidence available is to acknowledge the existence of this group spirit or mind, and to admit the influence that it has upon us. We may instance the "public school spirit," which perhaps we could wish was wider and better, as an example of this group spirit that is associated with every gathering of human beings. It grips the small boy as he enters the gates, dominates largely his school life and has a marked influence on the whole of his career. So also with the nation, the national ideals, attained through long centuries of striving, have their measure of effect on every individual in the race. We can see the enormous power behind this influence in the example provided when a wave of patriotism sweeps over a nation, and commits it to courses of action that may entail untold suffering on the whole community.

We are admittedly on very debatable ground, when discussing the mentality of a nation and this idea of a group mind. From a scientific point of view the study of it is very recent. We also have to take into account the actions of a crowd, promiscuously gathered, which often acts at a level far below that of the average individual, and which every member of it will regret in the light of reason that follows on reflection. Still these instances of the crowd that cries *à la lanterne* do but serve to emphasise the power behind this mass spirit. On the other hand we have groups and communities acting on an altruistic level that commands our genuine respect. The primitive individual is made up of a mixture of altruistic impulses and egoistic desires and, as McDougal says, "The group spirit destroys the opposition and the conflict between the crudely individualistic and the primitive altruistic tendencies of our nature. For it is the essence of the group spirit that the individual identifies himself, as we say, with the group more or less . . . so that he is moved to desire and to work for its welfare, its success, its honour and its glory."

The more we consider this group spirit the more we become convinced that it is subject to the same evolutionary progress as the body and mind of the individual is, and in this respect we probably find one of the most pleasing and encouraging aspects of modern life. It may be true that in bodily accomplishments and intelligence there is little between the Man of to-day and twenty-five thousand years ago. Within historical times it is certainly difficult to point out any striking advance in the individual. The poisons of the Borgia are equalled by the cocaine of to-day. Robin Hood and his merry men were no worse than our betting agents. The profligacy of the past can be matched in any of our big cities. The slaves of Rome were in no worse plight than the balance of unemployed now. The sculptors of ancient Greece still retain their position as masters of the art. We boast no rival to Shakespeare, and the salerooms still welcome the old master more than the new. A prophet has no honour in his own country, and we may add in his own time, but if we strip the glamour of age from the masterpieces and judge them on their merits alone we have to admit that poet, author, painter, architect and philosopher are no better to-day than they were ages ago.

Even in the realms of science we are but as little children playing with the pebbles on the shore of the ocean of knowledge. We marvel justly at the achievements that science has made possible. Wireless and the aeroplane would stagger our grandfathers with surprise and apprehension. Yet Columbus was as great as Rutherford; Babylon as wonderful as the sky-scraping city of to-day. Marconi, Ramsay and Edison have contributed no more than Plato, Galileo, Newton and Boyle. The philosophies of the past compare very favourably with those of the present, and ethical codes, enunciated almost daily, fall far short of that given in the Sermon on the Mount. There were giants in the past, and the glimpses we get of the average individual also show us a being very much like ourselves. Whatever point of view we take, we find very little to support the contention that the individual to-day is any better or worse than the individual far back in history.

There is no need, however, to go very far back to be convinced that under proper conditions the community ideals, the group mind, has progressed almost out of recognition. A century ago every civilised state tolerated a harshness and cruelty barely understandable now. In the British Navy punishments, causing insanity or painful death, were common and excited little comment. The administration of our criminal and poor laws, as depicted by Dickens, have no modern counterpart. The Reform Laws, the Factory Acts and many other national improvements of social conditions testify to the raising of the level of public opinion. It is of no avail to point out that a Shaftesbury, the super-individual was needed to reform the factories, or a Wilkes, the proto-individual to pave the way for a Reform Bill. Alone they were but voices crying in the wilderness; to effect the changes they had to appeal to and educate the crowd. The clamouring masses at the gates of Westminster are the real agents of progress. It is fashionable to speak of dictators, of despotic prime ministers and an all too powerful press, yet in the ultimate analysis the powers which these possess are based on an ability to gauge and cry aloud the beats of the pulse of the crowd. The crowd pushes the individual along before it. The man with ideas is still needed, but the path to a successful issue is *via* the crowd.

As we see it, the only advances that civilisation can claim are those which we sum up as the experience of the human race for many centuries, and which we suppose in some unexplained way is stored up in this group spirit. The problem that confronts us is to so adjust the future that the traditions of this spirit may become richer and fuller along the right direction. Certainly the problem is one which concerns the whole human race, it has no narrow national boundaries. It also concerns both body and mind. We have to aim at a sound body first, and this is a problem of heredity, which we have seen the biologist is beginning to understand. His successes will give us much more confidence in the application of measures of eugenics. To put this baldly we need to select the parents for the next generation to ensure that they shall possess the sound body in which a sane mind resides. As Professor Castle says, in such a selection " we are limited to such eugenic measures as the individual will voluntarily take in the light of present knowledge of heredity. It will do no good, but only harm, to magnify such knowledge unduly, or to conceal its present limitations. We should extend such knowledge as rapidly as possible, but not legislate until we are very sure of our ground."

This seems a counsel of passivity, but really we may look upon it as wise caution; but certainly at the present time we can agree with the author just quoted that " Cupid is a safer guide than a licensing board," provided that "the older persons who have been burned by the fire, or have seen others suffer in like fashion, should see that their children do not fall into the fire. For . . . civilisation has brought into being many perils which did not exist in a simpler and more primitive mode of living. Of these the young must be advised. Implicit trust in the guidance of instincts will in a civilised community lead to endless trouble." The realisation of this responsibility that we owe to coming generations, and the total destruction of a false prudery that ignores the problem of reproduction, will ensure that the children of the future will not suffer from bodies less sound than our own. Indeed it should make for improvement.

Mentally we have a more difficult problem, for we know actually less of the facts of the case. What the relationship between heredity and instincts is, is a very doubtful matter. Here we touch on the problem of education, in the sense of the considered actions of the mature on the immature. The days are gone when anyone imagined that, given the environment of a proper education, the individual could be moulded to a type, to be decided upon by the community. One might as well try to mould a cell of muscle tissue to perform the function of a cell in the retina of the eye. Yet it is possible that within this analogy which we have chosen we may find the beginning of a solution of our difficulty. The discovery that the body of animals was made up of tiny more or less separate cells led to the formation of a Cell Theory. "According to this idea the individuality of any organism arose from an integration of the individualities of its separate cells, and is thus a corporate individuality such as may exist in a school or regiment. Nowadays, however, opinion tends in the opposite direction—to regard the organism as an individual, with a common life running through it all, and the cells, not as units of which it is built up, but rather as parts into which it is divided in order to provide for the necessary division of labour involved in so complex a process as life."

May we not similarly view the life of the community as a whole, and turn our attention more to the evolution of the whole than to the individuals that compose it. Is not some such attitude of mind inherent in all the socialistic plans that beset the world at the present time? At their best, we all admit the soundness of the desires of their protagonists, even if at times we think they are modelled too much on the formal and stultifying model of an ant-hill. "Thus the group spirit, rising above the level of a narrow patriotism that regards with hostility all its rivals, recognising that only through the development of the collective life of a nation can man rise to higher levels than he has yet known, becomes the supreme agent of human progress."

This leads us back again to the very old idea of the family. It is the family that places the child in its correct position within the community, and the community will be strongest where this aim of family life is best recognised. The family is the training ground of the young mind, in which problems are presented within its comprehension. The one essential is the linking up of the family with that common stream of life that runs through the whole. It may be necessary under modern conditions to widen the scope of the family, and include our schools within it, and so make them true training grounds for the future. As mere pumps supplying knowledge they do little good, even if their products might succeed in passing weird examinations set by newspaper offices. The schools of the future must be an extension of the home, where the life of the community at its best may be absorbed by the pupils.

For our conclusion we may go back to the sentiments of Will Fern as expressed in "The Chimes." "Begin at the right end. Give us, in mercy, better homes when we're alying in our cradles; give us better food when we're aworking for our lives; give us kinder laws to bring us back when we're agoing wrong."

"Ignorance more frequently begets confidence than does knowledge: it is those who know little, not those who know much who so positively assert that this or that problem will never be solved by Science."

DARWIN.

BIBLIOGRAPHY

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