not the only bodies to travel round the sun. There are also the planets, Mercury and Venus, at distances of thirty−six and sixty−seven millions of miles; and beyond the circle of the earth and disregarding a belt of numerous smaller bodies, the planetoids, there are Mars, Jupiter, Saturn, Uranus and Neptune at mean distances of 141, 483, 886, 1,782, and 1,793 millions of miles respectively. These figures in millions of miles are very difficult for the mind to grasp. It may help the reader's imagination if we reduce the sun and planets to a smaller, more conceivable scale.

If, then, we represent our earth as a little ball of one inch diameter, the sun would be a big globe nine feet across and 323 yards away, that is about a fifth of a mile, four or five minutes' walking. The moon would be a small pea two feet and a half from the world. Between earth and sun there would be the two inner planets, Mercury and Venus, at distances of one hundred and twenty−five and two hundred and fifty yards from the sun. All round and about these bodies there would be emptiness until you came to Mars, a hundred and seventy−five feet beyond the earth; Jupiter nearly a mile away, a foot in diameter; Saturn, a little smaller, two miles off; Uranus four miles off and Neptune six miles off. Then nothingness and nothingness except for small particles and drifting scraps of attenuated vapour for thousands of miles. The nearest star to earth on this scale would be 40,000 miles away.

These figures will serve perhaps to give one some conception of the immense emptiness of space in which the drama of life goes on.

For in all this enormous vacancy of space we know certainly of life only upon the surface of our earth. It does not penetrate much more than three miles down into the 4,000 miles that separate us from the centre of our globe, and it does not reach more than five miles above its surface. Apparently all the limitlessness of space is otherwise empty and dead.

The deepest ocean dredgings go down to five miles. The highest recorded flight of an aeroplane is little more than four miles. Men have reached to seven miles up in balloons, but at a cost of great suffering. No bird can fly so high as five miles, and small birds and insects which have been carried up by aeroplanes drop off insensible far below that level.

II. The World in Time

IN the last fifty years there has been much very fine and interesting speculation on the part of scientific men upon the age and origin of our earth. Here we cannot pretend to give even a summary of such speculations because they involve the most subtle mathematical and physical considerations. The truth is that the physical and astronomical sciences are still too undeveloped as yet to make anything of the sort more than an illustrative guesswork. The general tendency has been to make the estimated age of our globe longer and longer. It now seems probable that the earth has had an independent existence as a spinning planet flying round and round the sun for a longer period than 2,000,000,000 years. It may have been much longer than that. This is a length of time that absolutely overpowers the imagination.

Before that vast period of separate existence, the sun and earth and the other planets that circulate round the sun may have been a great swirl of diffused matter in space. The telescope reveals to us in various parts of the heavens luminous spiral clouds of matter, the spiral nebulae, which appear to be in rotation about a centre. It is supposed by many astronomers that the sun and its planets were once such a spiral, and that their matter has undergone concentration into its present form. Through majestic aeons that concentration went on until in that vast remoteness of the past for which we have given figures, the world and its moon were distinguishable. They were spinning then much faster than they are spinning now; they were at a lesser distance from the sun; they travelled round it very much faster, and they were probably incandescent or molten at the surface. The sun itself was a much greater blaze in the heavens.

If we could go back through that infinitude of time and see the earth in this earlier stage of its history, we should behold a scene more like the interior of a blast furnace or the surface of a lava flow before it cools and cakes over than any other contemporary scene. No water would be visible because all the water there was would still be superheated steam in a stormy atmosphere of sulphurous and metallic vapours. Beneath this would swirl and boil an ocean of molten rock substance. Across a sky of fiery clouds the glare of the hurrying sun and moon would sweep swiftly like hot breaths of flame.

Slowly by degrees as one million of years followed another, this fiery scene would lose its eruptive incandescence. The vapours in the sky would rain down and become less dense overhead; great slaggy cakes of solidifying rock would appear upon the surface of the molten sea, and sink under it, to be replaced by other floating masses. The sun and moon growing now each more distant and each smaller, would rush with diminishing swiftness across the heavens. The moon now, because of its smaller size, would be already cooled far below incandescence, and would be alternately obstructing and reflecting the sunlight in a series of eclipses and full moons.

And so with a tremendous slowness through the vastness of time, the earth would grow more and more like the earth on which we live, until at last an age would come when, in the cooling air, steam would begin to condense into clouds, and the first rain would fall hissing upon the first rocks below. For endless millenia the greater part of the earth's water would still be vaporized in the atmosphere, but there would now be hot streams running over the crystallizing rocks below and pools and lakes into which these streams would be carrying detritus and depositing sediment.

At last a condition of things must have been attained in which a man might have stood up on earth and looked about him and lived. If we could have visited the earth at that time we should have stood on great lava−like masses of rock without a trace of soil or touch of living vegetation, under a storm−rent sky. Hot and violent winds, exceeding the fiercest tornado that ever blows, and downpours of rain such as our milder, slower earth to−day knows nothing of, might have assailed us. The water of the downpour would have rushed by us, muddy with the spoils of the rocks, coming together into torrents, cutting deep gorges and canyons as they hurried past to deposit their sediment in the earliest seas. Through the clouds we should have glimpsed a great sun moving visibly across the sky, and in its wake and in the wake of the moon would have come a diurnal tide of earthquake and upheaval. And the moon, which nowadays keeps one constant face to earth, would then have been rotating visibly and showing the side it now hides so inexorably.

The earth aged. One million years followed another, and the day lengthened, the sun grew more distant and milder, the moon's pace in the sky slackened; the intensity of rain and storm diminished and the water in the first seas increased and ran together into the ocean garment our planet henceforth wore.

But there was no life as yet upon the earth; the seas were lifeless, and the rocks were barren.

III. The Beginnings of Life

AS everybody knows nowadays, the knowledge we possess of life before the beginnings of human memory and tradition is derived from the markings and fossils of living things in the stratified rocks. We find preserved in shale and slate, limestone, and sandstone, bones, shells, fibres, stems, fruits, footmarks, scratchings and the like, side by side with the ripple marks of the earliest tides and the pittings of the earliest rain−falls. It is by the sedulous examination of this Record of the Rocks that the past history of the earth's life has been pieced together. That much nearly everybody knows to−day. The sedimentary rocks do not lie neatly stratum above stratum; they have been crumpled, bent, thrust about, distorted and mixed together like the leaves of a library that has been repeatedly looted and burnt, and it is only as a result of many devoted lifetimes of work that the record has been put into order and read. The whole compass of time represented by the record of the rocks is now estimated as

1,600,000,000 years.

The earliest rocks in the record are called by geologists the Azoic rocks, because they show no traces of life. Great areas of these Azoic rocks lie uncovered in North America, and they are of such a thickness that geologists consider that they represent a period of at least half of the 1,600,000,000 which they assign to the whole geological record. Let me repeat this profoundly significant fact. Half the great interval of time since land and sea were first distinguishable on earth has left us no traces of life. There are ripplings and rain marks still to be found in these rocks, but no marks nor vestiges of any living thing.

Then, as we come up the record, signs of past life appear and increase. The age of the world's history in which we find these past traces is called by geologists the Lower Palaeozoic age. The first indications that life was astir are vestiges of comparatively simple and lowly things: the shells of small shellfish, the stems and flowerlike heads of zoophytes, seaweeds and the tracks and remains of sea worms and crustacea. Very early appear certain creatures rather like plant−lice, crawling creatures which could roll themselves up into balls as the plant−lice do, the trilobites. Later by a few million years or so come certain sea scorpions, more mobile and powerful creatures than the world had ever seen before.

None of these creatures were of very great size. Among the largest were certain of the sea scorpions, which measured nine feet in length. There are no signs whatever of land life of any sort, plant or animal; there are no fishes nor any vertebrated creatures in this part of the record. Essentially all the plants and creatures which have left us their traces from this period of the earth's history are shallow−water and intertidal beings. If we wished to parallel the flora and fauna of the Lower Palaeozoic rocks on the earth to−day, we should do it best, except in the matter of size, by taking a drop of water from a rock pool or scummy ditch and examining it under a microscope. The little crustacea, the small shellfish, the zoophytes and algae we should find there would display a quite striking resemblance to these clumsier, larger prototypes that once were the crown of life upon our planet.

It is well, however, to bear in mind that the Lower Palaeozoic rocks probably do not give us anything at all representative of the first beginnings of life on our planet. Unless a creature has bones or other hard parts, unless it wears a shell or is big enough and heavy enough to make characteristic footprints and trails in mud, it is unlikely to leave any fossilized traces of its existence behind. To−day there are hundreds of thousands of species of small softbodied creatures in our world which it is inconceivable can ever leave any mark for future geologists to discover. In the world's past, millions of millions of species of such creatures may have lived and multiplied and flourished and passed away without a trace remaining. The waters of the warm and shallow lakes and seas of the so−called Azoic period may have teemed with an infinite variety of lowly, jelly−like, shell−less and boneless creatures, and a multitude of green scummy plants may have spread over the sunlit intertidal rocks and beaches. The Record of the Rocks is no more a complete record of life in the past than the books of a bank are a record of the existence of everybody in the neighbourhood. It is only when a species begins to secrete a shell or a spicule or a carapace or a lime−supported stem, and so put by something for the future, that it goes upon the Record. But in rocks of an age prior to those which bear any fossil traces, graphite, a form of uncombined carbon, is sometimes found, and some authorities consider that it may have been separated out from combination through the vital activities of unknown living things.

IV. The Age of Fishes

IN the days when the world was supposed to have endured for only a few thousand years, it was supposed that the different species of plants and animals were fixed and final; they had all been created exactly as they are to−day, each species by itself. But as men began to discover and study the Record of the Rocks this belief gave place to the suspicion that many species had changed and developed slowly through the course of ages, and this again expanded into a belief in what is called Organic Evolution, a belief that all species of life upon earth, animal and vegetable alike, are descended by slow continuous processes of change from some very simple ancestral form of

life, some almost structureless living substance, far back in the so−called Azoic seas.

This question of Organic Evolution, like the question of the age of the earth, has in the past been the subject of much bitter controversy. There was a time when a belief in organic evolution was for rather obscure reasons supposed to be incompatible with sound Christian, Jewish and Moslem doctrine. That time has passed, and the men of the most orthodox Catholic, Protestant, Jewish and Mohammedan belief are now free to accept this newer and broader view of a common origin of all living things. No life seems to have happened suddenly upon earth. Life grew and grows. Age by age through gulfs of time at which imagination reels, life has been growing from a mere stirring in the intertidal slime towards freedom, power and consciousness.

Life consists of individuals. These individuals are definite things, they are not like the lumps and masses, nor even the limitless and motionless crystals, of non−living matter, and they have two characteristics no dead matter possesses. They can assimilate other matter into themselves and make it part of themselves, and they can reproduce themselves. They eat and they breed. They can give rise to other individuals, for the most part like themselves, but always also a little different from themselves. There is a specific and family resemblance between an individual and its offspring, and there is an individual difference between every parent and every offspring it produces, and this is true in every species and at every stage of life.

Now scientific men are not able to explain to us either why offspring should resemble nor why they should differ from their parents. But seeing that offspring do at once resemble and differ, it is a matter rather of common sense than of scientific knowledge that, if the conditions under which a species live are changed, the species should undergo some correlated changes. Because in any generation of the species there must be a number of individuals whose individual differences make them better adapted to the new conditions under which the species has to live, and a number whose individual differences make it rather harder for them to live. And on the whole the former sort will live longer, bear more offspring, and reproduce themselves more abundantly than the latter, and so generation by generation the average of the species will change in the favourable direction. This process, which is called Natural Selection, is not so much a scientific theory as a necessary deduction from the facts of reproduction and individual difference. There may be many forces at work varying, destroying and preserving species, about which science may still be unaware or undecided, but the man who can deny the operation of this process of natural selection upon life since its beginning must be either ignorant of the elementary facts of life or incapable of ordinary thought.

Many scientific men have speculated about the first beginning of life and their speculations are often of great interest, but there is absolutely no definite knowledge and no convincing guess yet of the way in which life began. But nearly all authorities are agreed that it probably began upon mud or sand in warm sunlit shallow brackish water, and that it spread up the beaches to the intertidal lines and out to the open waters.

That early world was a world of strong tides and currents. An incessant destruction of individuals must have been going on through their being swept up the beaches and dried, or by their being swept out to sea and sinking down out of reach of air and sun. Early conditions favoured the development of every tendency to root and hold on, every tendency to form an outer skin and casing to protect the stranded individual from immediate desiccation. From the very earliest any tendency to sensitiveness to taste would turn the individual in the direction of food, and any sensitiveness to light would assist it to struggle back out of the darkness of the sea deeps and caverns or to wriggle back out of the excessive glare of the dangerous shallows.

Probably the first shells and body armour of living things were protections against drying rather than against active enemies. But tooth and claw come early into our earthly history.

We have already noted the size of the earlier water scorpions. For long ages such creatures were the supreme lords of life. Then in a division of these Palaeozoic rocks called the Silurian division, which many geologists now suppose to be as old as five hundred million years, there appears a new type of being, equipped with eyes and

teeth and swimming powers of an altogether more powerful kind. These were the first known backboned animals, the earliest fishes, the first known Vertebrata.

These fishes increase greatly in the next division of rocks, the rocks known as the Devonian system. They are so prevalent that this period of the Record of the Rocks has been called the Age of Fishes. Fishes of a pattern now gone from the earth, and fishes allied to the sharks and sturgeons of to−day, rushed through the waters, leapt in the air, browsed among the seaweeds, pursued and preyed upon one another, and gave a new liveliness to the waters of the world. None of these were excessively big by our present standards. Few of them were more than two or three feet long, but there were exceptional forms which were as long as twenty feet.

We know nothing from geology of the ancestors of these fishes. They do not appear to be related to any of the forms that preceded them. Zoologists have the most interesting views of their ancestry, but these they derive from the study of the development of the eggs of their still living relations, and from other sources. Apparently the ancestors of the vertebrata were soft−bodied and perhaps quite small swimming creatures who began first to develop hard parts as teeth round and about their mouths. The teeth of a skate or dog−fish cover the roof and floor of its mouth and pass at the lip into the flattened toothlike scales that encase most of its body. As the fishes develop these teeth scales in the geological record, they swim out of the hidden darkness of the past into the light, the first vertebrated animals visible in the record.

V. The Age of the Coal Swamps

THE LAND during this Age of Fishes was apparently quite lifeless. Crags and uplands of barren rock lay under the sun and rain. There was no real soil−for as yet there were no earthworms which help to make a soil, and no plants to break up the rock particles into mould; there was no trace of moss or lichen. Life was still only in the sea.

Over this world of barren rock played great changes of climate. The causes of these changes of climate were very complex and they have still to be properly estimated. The changing shape of the earth's orbit, the gradual shifting of the poles of rotation, changes in the shapes of the continents, probably even fluctuations in the warmth of the sun, now conspired to plunge great areas of the earth's surface into long periods of cold and ice and now again for millions of years spread a warm or equable climate over this planet. There seem to have been phases of great internal activity in the world's history, when in the course of a few million years accumulated upthrusts would break out in lines of volcanic eruption and upheaval and rearrange the mountain and continental outlines of the globe, increasing the depth of the sea and the height of the mountains and exaggerating the extremes of climate. And these would be followed by vast ages of comparative quiescence, when frost, rain and river would wear down the mountain heights and carry great masses of silt to fill and raise the sea bottoms and spread the seas, ever shallower and wider, over more and more of the land. There have been "high and deep" ages in the world's history and "low and level" ages. The reader must dismiss from his mind any idea that the surface of the earth has been growing steadily cooler since its crust grew solid. After that much cooling had been achieved, the internal temperature ceased to affect surface conditions. There are traces of periods of superabundant ice and snow, of "Glacial Ages," that is, even in the Azoic period.

It was only towards the close of the Age of Fishes, in a period of extensive shallow seas and lagoons, that life spread itself out in any effectual way from the waters on to the land. No doubt the earlier types of the forms that now begin to appear in great abundance had already been developing in a rare and obscure manner for many scores of millions of years. But now came their opportunity.

Plants no doubt preceded animal forms in this invasion of the land, but the animals probably followed up the plant emigration very closely. The first problem that the plant had to solve was the problem of some sustaining stiff support to hold up its fronds to the sunlight when the buoyant water was withdrawn; the second was the problem