The writer has told how it grew out of notes and maps, and he will confess that now when he turns over the earlier editions, the first edition that was published in parts and the first book edition of 1920, he finds the flavour of notebook altogether too strong. Much undigested and discordant matter was put into footnotes; there were far too many hesitating, ambiguous and guarded statements; the presentation was sometimes confused. The method he pursued led naturally to that. He called in to his aid four chief helpers, Sir Ray Lankester, Professor Gilbert Murray, Sir Harry Johnston and Mr. Ernest Barker, and he made them his advisers upon his reading and sources of information. In addition he secured the help and advice of various specially well-read men upon this or that point or region. Sir Denison Ross, Mr. Cranmer Byng and Mr. S. N. Fu, for example, were extremely helpful in regard to Central Asia and China, Dr. Charles Singer gave the most useful information upon classical science, Professor J. L. Myres was a valuable source for Mediterranean archæology, Mr. Philip Guedalla was his counsellor upon European politics in the eighteenth and early nineteenth centuries; and so forth and so on. Mr. J. F. Horrabin, with his genius for political and commercial geography, was not so much an illustrator as a collaborator. There were many others who gave their time and knowledge freely and generously; there are full lists of names in the previous editions; one hesitates between acknowledging one's obligations and implicating one's friends. Each chapter was first drafted by the author, multiple copies were made and sent out to all the possible helpers, who wrote, commented and slashed about upon them, as they thought proper. The author then sat down, chastened and instructed, amidst these mutilated and butchered duplicates, and wrote his chapter afresh. Finally proofs went out to all the chief helpers and to anyone else especially interested in the period dealt with.

In this way the correctness of names, dates and so forth was ensured. But though the writer upon all questions of fact followed with absolute fidelity the band of tutors he had evoked, he reserved to himself the fullest rights of private judgment upon matters of opinion. The result was the introduction of various lively controversies into the clustering footnotes and even into the text. For example, he fell foul of Professor Gilbert Murray in a comparison of the moral and intellectual quality of the common Athenian and of the Cockney, and though he conceded to his editor the completest intimacy with the former he maintained the right to judge the latter in his own fashion. There was also a page or so of disputation between the writer, Professor Murray and Mr. Barker, about the soundness of Mr. Gladstone's education. And various differences with Mr. Ernest Barker. To the writer the "greatness" of Napoleon I is a monstrous and altogether unsubstantial superstition. The facts, he thinks, speak for themselves, and they will be given in this *Outline* in their proper place and proportion. The man was of the quality of Mussolini and intellectually inferior to Napoleon III. But Mr. Barker was unable to

accept this statement. "Put me down of the opposite opinion," he wrote, and so the footnote stood. Sir Harry Johnston's weakness—or rather his excessive strength—lay in the abnormal, though no doubt righteous, spelling of well-known historical names. He would have Solomon, Shelomoh, and Hebrews, Ibrim, which seemed likely to be difficult and confusing for the ordinary reader. That issue also flowered into footnotes.

These footnotes were as amusing to the writer and his friends as family jokes, and they were almost inevitable while the names of the four chief helpers stood with the writer's upon the title page, upholding and in a way guaranteeing it; but they were perplexing and tedious to most readers. Footnotes, references and qualifications are necessary things in a book written for the student, but in this *Outline* they were superfluous and even, the writer now confesses, a little pretentious. He has now released his four chief helpers, with gratitude, from all further responsibility. Their names have disappeared from the title page. He has dropped his pilots. They steered him past dangerous shoals, and along tortuous channels to his present freedom and confidence. And so helped and liberated he is able to simplify, clarify and give its fullest values to this great story their kindness made it possible for him to tell.

This work has now been completely reprinted many times. The first publication in parts subjected it chapter by chapter to the scrutiny of over a hundred thousand readers. Many wrote offering comments, pointing out small errors, raising interesting points. All this correspondence was dealt with systematically and the first book edition benefited greatly in detail. That also went out to a great multitude of readers; in America alone over a quarter of a million copies were issued, and that again produced an abundant crop of emendations. That edition also evoked many able reviews and several critical pamphlets appeared. The second book edition in 1923, the third edition, that is, profited greatly by that second extensive examination. In addition to such revisions of detail the chapters of the third edition were rearranged. For some time the author had felt that his account of the Aryan people came too early and minimized the share of the non-Aryan races in the development of civilization. He altered the order of the earlier chapters so as to correct this effect. And also he inserted a fuller account of Lincoln and the American Civil War. The 1930 edition involved still further additions and revisions. It was purged of footnotes and digressions and made more explicit, more fluent and more continuous than its predecessors. The disputes of the collaborators were no longer heard behind the scenes. It lost, the writer hopes, its last traces of the student's notebook and became plainly and simply an *Outline of History*.

The reader of this book need be in no doubt about the facts, the names, the dates that are given here—after the test of these scrutinies and revisions The book has been severely criticized, but never on the score of its general accuracy. Even so inveterate an antagonist of the

writer as Mr. Belloc has conceded it that much merit. The objections made concern the relative prominence given to this part or that, to the influence of this culture or the importance of that. A certain type of classical scholar rages at the comparative neglect of Homer and the æsthetic side of Greek life, though the account of Greek science is full, and though the intellectual development of Greece is treated as a cardinal phase in human development. Another large body of opinion sees the world through Latin forms and is exasperated even by the simple statement of the comparative extent, duration and influence of, for instance, the Byzantine, Persian and Chinese systems. Rome is still aggressive in modern literature and criticism, and still seeks to minimize the non-Latin spaces in the picture. Dogmatic Freethinkers, again, consider the acceptance of Jesus as a real person insupportable; adherents of Islam cry out against the too familiar handling of their prophet. Communists are offended because the doctrines of Marx and Lenin are not made the basis of the entire story. Many people, with a rather materialistic theology in their minds, have been disagreeably impressed by the massed and accumulating evidences of man's animal descent. Even if that be true they think it is highly demoralizing. Such criticisms were inevitable. There was no way of evading or satisfying these demands.

One realizes in the face of such attitudes and objections that nearly everyone has already a sort of implicit Outline of History in his mind, his working explanation of his world and of his place in the world, rejecting this view and assuming that, and more or less clear-mindedly he brings our version to the test of these half-buried acceptances. And naturally the writer, too, has his view, his bias. But the reader will never find a writer who has not that much personality. There never will be an Outline of History written that is not tendential. Here, as in every sort of descriptive and informative book, the reader has to bear in mind, just as a judge or a juryman has to bear in mind, the individual characteristics of the witness who is giving his account of what he saw. What is claimed here is that the witness does to the best of his ability tender a fair and honest general account from his point of view of the great spectacle of Time and Fate that has unfolded itself before him.

§ 3

Of Certain Omissions and Additions.

In the criticism of the earlier editions of this *Outline*, the complaint was frequently repeated that the development of the arts, and particularly of music, was disregarded. The story of man's achievement of knowledge and social power was given at considerable length, but hardly anything was said of the appearance and extension of his conscious search for beauty. An attempt was later made to meet

these objections and several sections have been added to record how the artist, the poet and the imaginative writer appeared in human life. Yet the limitations upon any "history" of music or any other art are very narrow. One may note the appearance of new forms, new methods, new instruments, but the only way to the realization of imaginative art is to hear it or see it or read it. It is no part of our plan to catalogue masters and masterpieces and help our readers to babble great names.

Additions have been made necessary by the progress of the excavator. It is hard nowadays for the writer to keep pace with the spade. Moreover it has been necessary to scrutinize the account of the First World War very closely and to rearrange and in part rewrite the post-war portion. That was much the weakest part of the preceding editions. The exciting hopes and stresses of the time were too close for restrained writing. There was a lack of proportion between this conclusion and the rest of the book; speeches by Mr. Lloyd George, the perfidies of the Irish struggle, lectures by obscure generals at the United Service Institution loomed portentous. Something of the pamphleteer, something of the partisan, came in. This latter part has been severely pruned, and a fresh attempt to give a sounder analysis of the world-outlook has been made. It is not only in the political field that things have had to be thought out again. The nature of the financial and economic difficulties of the world has become much plainer now than it was before the crisis of 1929, and this again has necessitated very careful revision.

§ 4

Of Two Other Outlines.

The Outline of History proved an extremely successful book. Its extraordinary reception astonished both its publishers and its author. It revealed the existence of a new immense stratum of intelligent people in the modern community eager and ready to supply the deficiencies of school and college education. It was the world-wide need for such a general view of historical fact, far more than any literary merit of the *Outline*, which brought about this enormous sale.

The discovery of this great mass of inquiring minds, with all the political and social possibilities it revealed, was necessarily extremely stimulating to the writer of the *Outline* and his associates They realized that here was a new element in the world's affairs: a great and as yet disorganized multitude capable of a modern ideology and needing only to be drawn together by a common system of knowledge and understandings, to become a dominating influence in the reconstruction in human affairs. It seemed almost ungrateful not to serve this receptive multitude to the utmost. It was not that those responsible for the *Outline* had any great conceit of themselves as leaders, but that the good fortune of that book had put them into a position of exceptional advantage to go on and complete the work of

which the *Outline* was manifestly only a part. The responsibility of their opportunity far exceeded their powers. The *Outline* gave the framework of international ideas; it was a basis for political thought and activity, but it left certain other fields of universal human interest untouched. Nobody had such a chance of getting these gaps filled in a reasonably short space of time, if he could do it, as the writer of the *Outline*.

So there has now sprung from this beginning two other enterprises, which round off and complete a working statement of the general picture of our world needed by the modern citizen. The first of these is an outline of biological science, a statement of all that is currently known about the life in us and round us, our health, our mental activity, our origins, and the whole story of life's evolution since the beginning. This the writer has done in intimate collaboration with two able biologists, his son, G. P. Wells, and the grandson of his former professor, Professor Julian Huxley. They have made an up-to-date summary of all biological knowledge. For reasons that need not be gone into here, they have not called this work, *The Outline of Life*, but *The Science of Life*.

But still there was left a third main aspect of human existence, and that was the business existence, the work, anxiety, effort, pressure of everyday life. *The Outline of History* told a man of his origins and tradition, why war hung over him, and why he was under the law; *The Science of Life* told him of the nature of his bodily and mental life; the third outline to complete the exposition of his world had to be an outline of economics, of how and why man worked, why money has become essential to his well-being and his relations to his fellow creatures, and the general "go" of industry, wealth-winning and earning and spending. This again it was found better not to call an Outline, and after many changes of title it has been completed and is now published as *The Work, Wealth and Happiness of Mankind*. So the first statement from a modern standpoint of what man was and is and what he does is completed.

These works are offered to the world without arrogance and without compunction. They are no doubt faulty to a terrible extent, and in due course they will certainly be superseded by far better work upon the same lines. They are like the temporary sheds that precede a palace. Their substance will need condensation and simplification for school use into an elementary Account of Life for the young, and various portions of them may need expansion for the college student. But until they are so superseded these three works remain, in their pioneer and experimental fashion, a necessary bringing together of what a contemporary man or woman can know about the past, about self, and about the daily task.

H. G. W.

The preceding sections are left as Wells wrote them, with only such changes as are necessary to make sense after the passing of the years. He intended to make a further serious revision. At intervals, as the preface shows, he added sections to bring the *Outline* up to date; but they were episodic and had faults of which he was probably conscious. Certainly, there exists a copy which he had begun to correct, and in which everything after about 1930 is struck out in the "Table of Contents". All his detailed corrections have, of course, been incorporated in this edition; the most interesting of them are those that show a modification of his views upon the Russian revolution. Several of the more offensive adjectives had been removed.

In this edition I have found practically nothing of importance to alter up to the date where he had made his great crossing-out. Where I have had to change anything previously, it has always been because of an alteration in our knowledge, not because of an error. The planet Pluto has been discovered and so have several fossil men; the British Queen is no longer "Empress of India"; and therefore some phrases have had to be modified. That is all; the monumentally solid quality of the body of the work has only been proved by time.

In later years I have naturally had to make more changes, but I have always endeavoured to remember, where doubt exists, that readers wish to hear the views of Wells, not those of Postgate; for that reason I have sometimes let stand judgments that would not be my own. I have also had to rewrite whole sections which Wells had merely sketched out. Those who are interested may note that Chapters 6 to 9 have been extensively revised by G. P. Wells and myself, that much of section 7 and all of sections 9, 12 and 13 of Chapter 39 are from my hand, and that the concluding chapter is wholly my own; all the rest is substantially H. G. Wells's.

R. W. P.

THE OUTLINE OF HISTORY

BOOK I

THE WORLD BEFORE MAN

CHAPTER 1

THE EARTH IN SPACE AND TIME

§ 1

AND first, before we begin the history of life, let us tell something of the stage upon which our drama is put and of the background against which it is played.

In the last few hundred years there has been an extraordinary enlargement of men's ideas about the visible universe in which they live. At the same time there has been perhaps a certain diminution in their individual self-importance. They have learnt that they are items in a whole far vaster, more enduring and more wonderful than their ancestors ever dreamed or suspected.

To the savage and primitive mind the earth seems to be the whole flat floor of the universe; the sky is a dome above it across which the sun and moon and stars pass and pass again, returning by some mysterious roundabout or subterranean route. The Babylonian and Chinese astronomers, after many centuries of star observation, still believed that the earth was flat. It was the Greek mind which first grasped clearly the spherical form of the world, but even so, it did not apprehend the universe as relatively very large. The globe of earth was the centre of being; the sun, the moon, the planets, the fixed stars, moved about it as their centre, in crystalline spheres. It was only in the fifteenth century that men's minds moved beyond this, and

Copernicus made his amazing guess that the sun was the centre and not the earth. It was only with the development of the telescope by Galileo in the opening of the seventeenth century that the views of Copernicus became widely accepted.

The development of the telescope marks, indeed, a new phase in human thought, a new vision of life. It is an extraordinary thing that the Greeks, with their lively and penetrating minds, never realized the possibilities of either microscope or telescope. They made no use of the lens. Yet they lived in a world in which glass had been known and had been made beautifully for hundreds of years; they had about them glass flasks and bottles, through which they must have caught glimpses of things distorted and enlarged. But science in Greece was pursued by philosophers in an aristocratic spirit, men who, with a few such exceptions as the ingenious Archimedes and Hiero, were too proud to learn from such mere artisans as jewellers and metal- and glass-workers.

Ignorance is the first penalty of pride. The philosopher had no mechanical skill and the artisan had no philosophical education, and it was left for another age, more than a thousand years later, to bring together glass and the astronomer. Since the time of Galileo astronomy and the telescope have advanced together, and a veil of ignorance and false assumptions has been rolled back from the deeps of space. The idea that the sun was the centre of the universe has followed the idea that the world was in that position. We know now that our sun cannot even be included among the greatest of the stars; it is merely one of the lesser lights.

The telescope has released the human imagination as no other implement has ever done. If there is any other apparatus worthy to be compared to its enlarging influence, it is the spectroscope, which was developed after the discoveries of Fraunhofer, the glass-worker, in 1814. Since man has lived on earth he has seen rainbows, but who could have told him that those bands of colour held in them a promise that one day he should be able to analyse the stars? But the spectroscope receives the rays from any luminous source, passes them through prisms, and breaks them up into rainbow-like bands. These bands reveal under examination transverse lines of brightness and darkness which vary with the heat and the chemical composition of the source of light and of any intervening vapour. So that men can now sit in observatories and learn the composition and take the temperature of stars incalculable billions of miles away.

The curtain that hid the unfathomable abyss of stellar distances has been drawn back only in the last three centuries. Still more recent is our realization of the immense duration of our universe in time. Among ancient peoples the Indian philosophers alone seem to have had any perception of the vast ages through which existence has passed. In the European world, until little more than a century and a half ago, men's ideas of the time things had lasted were astonishingly brief. In the *Universal History*, published by a syndicate of booksellers in London in 1779, it is stated that the world was created in 4004 B.C. and (with a pleasant exactitude) at the autumnal equinox, and that the making of man crowned the work of creation at Eden, upon the Euphrates, exactly two days' journey above Basra. The confidence of these statements arose from a too literal interpretation of the Bible narrative. Very few even of the sincerest believers in the inspiration of the Bible now accept them as matter-of-fact statements.

It is the science of geology and particularly the science of palæontology which has broken through this time barrier and opened beyond that little yesterday of scarcely six thousand years a million such yesterdays. Two main sets of facts, very frequently observed, were forcing themselves upon men's attention long before the eighteenth century. One was that in innumerable districts one saw exposed great thicknesses of stratified rocks that could only have been accumulated during long periods of time, and that in many cases these strata had been bent, contorted, and thrust about in a way that was inevitably suggestive of enormous forces operating through long periods of time. The other was the existence of fossils similar to, but not precisely like, the bones and skulls and other hard parts of existing species.

It was only in the eighteenth century that strata and fossils began to be studied systematically; it is only in the nineteenth that the recognition of the real scale and quality of these accumulations, the *Record of the Rocks*, became widespread. There was a great struggle to establish the authority of the Record against the prejudices of those to whom a strictly literal interpretation of the Bible was dear. Many men still living took an active part in that great emancipation of the human mind. Gradually the perspectives of mankind changed and elongated. Two hundred years ago the imagination of our race had a background of six thousand years. Now that curtain has risen also, and men look back to a past of scores and hundreds of millions of years.

§ 2

The Earth in Space.

We will now summarize very compactly what is known of the material dimensions of our world. Our earth, it has been shown, is a spinning globe. Vast though it seems to us, it is a mere speck of matter in the greater vastness of space.

Space is, for the most part, emptiness. At great intervals in this emptiness there are flaring centres of heat and light, the "fixed stars." They are all moving about in space, notwithstanding that they are called fixed stars, but for a long time men did not realize their motion. They are so vast and at such tremendous distances that their motion is not perceived. Only in the course of many thousands of years is it appreciable. Scores of centuries ago the Egyptians made star-maps, and they show us that the shapes of the constellations have changed very considerably; many stars have moved measurably. Yet we still use the old convenient expression "fixed stars" to distinguish them from the planets. These fixed stars are so far off that, for all their immensity, they seem to be, even when we look at them through the most powerful telescopes, mere points of light, brighter or less bright. A few, however, when we turn a telescope upon them, are seen to be whirls and clouds of shining vapour which we call nebulæ. They are puffs and smears of luminous stuff, billions of miles in length. They are so far off that a movement of millions of miles would be imperceptible.

There are also, it has been realized quite recently, a number of "dark bodies" in space, and clouds of opaque matter—some of enormous size. We should still know nothing of their existence if it had not been that they blot out the luminous stars beyond them.

One star, however, is so near to us that it is like a great ball of flame. This one is the sun. The sun is itself in its nature like a fixed star, but it differs from the other stars in appearance because it is beyond comparison nearer than they are; and because it is nearer men have been able to learn something of its nature. Its mean distance from the earth is ninety-three million miles. It is a mass of flaming matter, having a diameter of 866,000 miles. Its bulk is a million and a quarter times the bulk of our earth. Many of the fixed stars are vastly greater.

These are difficult figures for the imagination. If a bullet

fired from a Maxim gun at the sun kept its muzzle velocity unimpaired, it would take seven years to reach the sun. And yet we say the sun is quite close, measured by the scale of the stars. If the earth were a small ball, one inch in diameter, the sun would be a globe of nine feet diameter; it would fill a small bedroom. We know now that it is spinning round on its axis, but since it is an incandescent fluid, its polar regions do not travel with the same velocity as its equator, the surface of which rotates in about twenty-five days. The surface visible to us consists of clouds of incandescent metallic vapour. So hot is the sun's atmosphere that iron, nickel, copper, and tin are present in it in a gaseous state. At what lies below we can only guess.

About the sun at great distances circle not only our earth, but certain other kindred bodies called the planets. These shine in the sky because they reflect the light of the sun; they are near enough to us to note their movements quite easily. Night by night their positions change with regard to the fixed stars.

It is well to understand how empty of matter is space. If, as we have said, the sun were a globe nine feet across, our earth would, in proportion, be the size of a one-inch ball, and at a distance of 322 yards from the sun. This is over a sixth of a mile. It would mean 3½ minutes' smart walking from the ball to the nine-feet globe. The moon would be a speck the size of a small pea, thirty inches from the earth.

Nearer to the sun than the earth would be two other very similar specks, the planets Mercury and Venus, at a distance of a hundred and twenty-four and two hundred and thirty-two yards respectively. Beyond the earth would come the planets Mars, Jupiter, Saturn, Uranus, Neptune and Pluto at distances from the sun of 488, 1,672, 3,067, 6,169, 9,666 and 13,300 yards respectively. From the sun to Neptune would be a two-hour walk. There would also be a certain number of very much smaller specks, flying about amongst these planets, more particularly a number called the asteroids circling between Mars and Jupiter, and occasionally a little puff of more or less luminous vapour and dust would drift into the system from the almost limitless emptiness beyond. Such a puff is what we call a comet. *All the rest of the space about us and around us and for unfathomable distances beyond is cold, lifeless, and void.* The nearest fixed star to us, *on this minute scale,* be it remembered—the earth as a one-inch ball, and the moon a little pea—would be over 40,000 miles away! Most of the fixed stars we see would still be *on this scale* scores and hundreds of millions of miles off.

Let us come back now to the earth. The diameter of our world is a little under 8,000 miles. Its surface is rough, the more projecting parts of the roughness are mountains, and in the hollows of its surface there is a film of water, the oceans and seas. This film of water is about five miles thick at its deepest part—that is to say, the deepest oceans have a depth of five miles. This is very little in comparison with the bulk of the world.

About this sphere is a thin covering of air, the atmosphere. As we ascend in a balloon or go up a mountain the air is continually less dense, until it becomes too thin to support life. At a height of twenty miles there is scarcely any air at all. The highest point to which a bird can fly is about four miles up—the condor, it is said, can struggle up to that; but most small birds and insects which are carried up by aeroplanes or balloons drop off insensible at much lower level. Balloons with men in them have reached very nearly seven miles, but at the cost of considerable physical suffering. Aeroplanes with pressurized cabins which reproduce the conditions at the earth's surface have flown even higher, and projectiles have carried living things very much farther away—but only by carrying an artificial sample of the earth's atmosphere as well.

It is only in the upper few hundred feet of the crust of the earth, in the sea, and in the lower levels of the air below four miles that life naturally occurs. We do not know of any life except in these really very shallow films of air and water upon our planet. So far as we know, all the rest of space is as yet uninhabited. Scientific men have discussed the possibility of life, or of some process of a similar kind, occurring upon such kindred bodies as the planets Venus and Mars. But they point merely to questionable possibilities.

§ 3

How Long has the Earth Endured?

So much for the Earth in space. Let us now consider our subject from the point of view of time. Astronomers and geologists and those who study physics are now able to tell us something of the origin of the earth. The classical theory is that, vast ages ago, the sun was a spinning, flaring mass of matter, not yet concentrated into a compact centre of heat and light, considerably larger than it is now, and spinning very much faster, and that as it whirled a series of fragments were detached from

it and became the planets. Our earth is one of these planets. The flaring mass that was the material of the earth broke into two masses as it spun; a larger, the earth itself, and a smaller, which is now the dead, still moon.

Astronomers give us convincing reasons for supposing that sun and earth and moon and all that system were then whirling about at a speed much greater than their speed to-day, and that at first our earth was a flaming thing upon which no life could live. They oblige us to believe that the sun, incandescent though it is, is now much cooler than it was, and that it spins more slowly now than it did, and that it continues to cool and slow down. And they also show that the rate at which the earth spins is diminishing and continues to diminish—that is to say, that our day is growing longer and longer, and that the heat at the centre of the earth wastes slowly. There was a time when the day was not a half and not a third of what it is to-day; when a blazing hot sun, much greater than it is now, must have moved visibly—had there been an eye to mark it—from its rise to its setting across the skies. There will be a time when the day will be as long as a year is now, and the cooling sun, shorn of its beams, will hang motionless in the heavens.

How long, some reader will ask, has the world endured? That is a question which has attracted much attention in the last few years. Gradually the earlier estimates, which varied very widely, have been brought towards agreement. Astronomers and mathematicians who base their computations on the rate of cooling of celestial bodies and in various processes of diffusion and atomic change give us 2,000 million years as the age of the earth as a body separate from the sun, and about 300 million years as the length of time since life appeared upon it in any abundance. The age of the sun as a star is now supposed to be somewhere in the nature of five million million years. The earth, says Sir James Jeans in his *Universe Around Us*, will in all probability go on for another million million years and then its equatorial temperature may be sinking to Arctic conditions. Since man has existed as a self-conscious social creature for only a few tens of thousands of years, this gives him illimitable opportunity for the attainment of knowledge and power. Long before he reaches that limit he may make himself master of time and space.

CHAPTER 2

THE RECORD OF THE ROCKS

§ 1. *The First Living Things.* § 2. *Natural Selection and the Changes of Species.*

§ 1

We do not know certainly how life began upon the earth.

Biologists have made many guesses and suggestions, and there seems to be a general agreement that life began in warm sunlit shallow water, possibly in pools and lagoons along the coasts of the first formed seas. It began perhaps as a slime, as a sort of sub-life that slowly and imperceptibly took on the distinctive qualities of life. Upon no part of earth at present are there the sort of conditions, chemical and physical, under which life can conceivably have begun. There is certainly no fresh beginning of life going on now. But out of inorganic matter it is possible to make slimes and films that faintly parody the structure, and even the spreading and growth, of living things. If the beginning of life was a natural unmiraculous process, then surely some day it will be possible for the man of science to imitate and repeat it. Until that can be done this question necessarily remains to a certain extent speculative. And if many biologists are convinced that life appeared under the requisite conditions as naturally and inevitably as ice appears when water under the normal pressure is cooled below the freezing-point, it is also the case that many other people of equal intelligence are of an opposite opinion. Here we cannot be expected to adjudicate upon the question.

The idea that life appeared on the earth as a natural and necessary chemical and physical process, without the intervention of any miraculous factor, seems to be very repugnant to many religious minds. But that repugnance is due, perhaps, rather to a confusion of thought in these minds than to any essential irreligiosity in the conception itself. They think of "life" as being in a way already "soul," they ascribe all sorts of moral qualities to it; they side with it against "dead matter." But it is difficult to see why a slug or a toadstool, a louse or a

cancerous parasitic growth upon the bark of a tree, should be treated as though it and the processes of its existence were in some mysterious way "higher" than, for example, the beautifully marshalled elements in a crystalline group, or in a gem, or in a slab of patterned marble, or the lovely patternings of rippled water in the sunlight, or the undulations of wind-blown sand. Why should the maker of the universe take sides between the almost inanimate and the altogether inanimate?

The atmosphere was much denser in the days of life's beginning; usually great cloud masses obscured the sun, frequent storms darkened the heavens. The land of those days, upheaved by violent volcanic forces, was a barren land, without vegetation, without soil. Almost incessant rain-storms swept down upon it, and rivers and torrents carried great loads of sediment out to sea, to become muds that hardened later into slates and shales, and sands that become sandstones.

The geologists have studied the whole accumulation of these sediments as it remains to-day, from those of the earliest ages to the most recent. Of course the oldest deposits are the most distorted and changed and worn, and in them there is now no certain trace to be found of life at all. Probably the earliest forms of life were small and soft, leaving no evidence of their existence behind them. It was only when some of these living things developed skeletons and shells of lime and such-like hard material that they left fossil vestiges after they died, and so put themselves on record for examination.

The literature of geology is very largely an account of the fossils that are found in the rocks and of the order in which layers after layers of rocks lie one on another. The very oldest rocks must have been formed before there was any sea at all, when the earth was too hot for a sea to exist, and when the water that is now sea was an atmosphere of steam mixed with the air. The higher levels of the atmosphere were dense with clouds, from which a hot rain fell towards the rocks below, to be converted again into steam long before it reached their incandescence. Below this steam atmosphere the molten world-stuff solidified as the first rocks. These first rocks must have solidified as a cake over glowing liquid material beneath, much as cooling lava does. They must have appeared first as crusts and clinkers. They must have been constantly remelted and recrystallized before any thickness of them became permanently solid. The scenery of the world in these days must have been

more like the interior of an electric furnace than anything else to be found upon earth at the present time.

After long ages the steam in the atmosphere began also to condense and fall right down to earth, pouring at last over these warm primordial rocks in rivulets of hot water and gathering in depressions as pools and lakes and the first seas. Into those seas the streams that poured over the rocks brought with them dust and particles to form a sediment, and this sediment accumulated in layers, or, as geologists call them, *strata*, and formed the first sedimentary rocks. Those earliest sedimentary rocks sank into depressions and were covered by others; they were bent, tilted up, and torn by great volcanic disturbances and by tidal strains that swept through the rocky crust of the earth. We find these first sedimentary rocks still coming to the surface of the land here and there, either not covered by later strata or exposed after vast ages of concealment by the wearing off of the rock that covered them later—there are great surfaces of them in Canada especially; they are cleft and bent, partially remelted, recrystallized, hardened and compressed, but recognizable for what they are. And they contain no single certain trace of life at all.

They are frequently called *Azoic* (lifeless) rocks. But since in some of these earliest sedimentary rocks a substance called graphite (black lead) occurs, and also red and black oxide of iron, and since it is asserted that these substances need the activity of living things for their production, which may or may not be the case, some geologists prefer to call these earliest sedimentary rocks *Archæozic* (primordial life). They suppose that the first life was soft living matter that had no shells or skeletons or any such structure that could remain as a recognizable fossil after its death, and that its chemical influence caused the deposition of graphite and iron oxide. This is pure guessing, of course, and there is at least an equal probability than in the time of formation of the Azoic rocks life had not yet begun.

Overlying or overlapping these Azoic or Archæozoic rocks come others, manifestly also very ancient and worn, which do contain traces of life. These first remains are of the simplest description; they are the vestiges of simple plants called Algæ, or marks like the tracks made by worms in the sea mud. There are also the skeletons of the microscopic creatures called Radiolaria. This second series of rocks is called the *Proterozoic* (beginning of life) series, and marks a long age in the world's history.

Lying over and above the Proterozoic rocks is a third series, which is found to contain a considerable number and variety of traces of living things. First comes the evidence of a diversity of shell-fish, crabs and such-like crawling things, worms, sea-weeds, and the like; then of a multitude of fishes and of the beginnings of land plants and land creatures. These rocks are called the *Palæozoic* (ancient life) rocks. They mark a vast era, during which life was slowly spreading, increasing, and developing in the seas of our world. Through long ages, through the earliest Palæozoic time, it was no more than a proliferation of such swimming and creeping things in the water. There were creatures called trilobites; these were crawling things like big sea wood-lice, and they were probably related to the American king-crab of to-day. They were also sea-scorpions, the prefects of that early world. The individuals of certain species of these were nine feet long. These were the very highest sorts of life. There were abundant different sorts of an order of shell-fish called brachiopods. There were plant animals, rooted and joined together like plants, and loose weeds that waved in the waters.

It was not a display of life to excite our imaginations. There was nothing that ran or flew or even swam swiftly or skilfully. Except for the size of some of the creatures, it was not very different from, and rather less various than, the kind of life a student would gather from any summer-time ditch nowadays for microscopical examination.

Such was the life of the shallow seas through a couple of hundred million years in the early Palæozoic Period. The land during that time was apparently absolutely barren. We find no trace nor hint of land life. Everything that lived in those days lived under water for most or all of its life. For ages that stagger the imagination that was all that there was of life, and before that time the earth had spun hot and lifeless for hundreds of millions of years.

Between the formation of these Lower Palæozoic rocks in which the sea-scorpion and trilobite ruled and our own time there have intervened almost immeasurable ages represented by layers and masses of sedimentary rocks. There are first the Upper Palæozoic rocks, and above these the geologists distinguish two great divisions. Next above the Palæozoic come the *Mesozoic* (middle life) rocks, a second vast system of fossil-bearing rocks, representing perhaps a hundred and fifty millions of swift years, and containing a wonderful array of fossil remains, bones of giant reptiles, and the like, which we will

presently describe; and above these again are the *Cenozoic* (recent life) rocks, a mere fifty million years in length but a third great volume in the history of life, an unfinished volume of which the sand and mud that were carried out to sea yesterday by the rivers of the world, to bury the bones and scales and bodies and tracks that will become at last fossils of the things of to-day, constitute the last written leaf.

The markings and fossils in the rocks, and the rocks themselves, are the first historical documents. The history of life that men have puzzled out and are still puzzling out from them is called the Record of the Rocks. But when we call these rocks and the fossils a record and a history, it must not be supposed that there is any sign of an orderly keeping of a record. It is merely that whatever happens leaves some trace, if only we are intelligent enough to detect the meaning of that trace. Nor are the rocks of the world in orderly layers one above the other convenient for men to read. They are not like the books and pages of a library. They are torn, disrupted, interrupted, flung about, defaced, like a carelessly arranged office after it has experienced in succession a bombardment, a hostile military occupation, looting, an earthquake, riots, and a fire. And so it is that for countless generations this Record of the Rocks lay unsuspected beneath the feet of men. Fossils were known to the Ionian Greeks in the sixth century B.C., they were discussed at Alexandria by Eratosthenes and others in the third century B.C., a discussion which is summarized in Strabo's *Geography* (? 20–10 B.C.). They were known to the Latin poet Ovid, but he did not understand their nature. He thought they were the first rude efforts of creative power. They were noted by Arabic writers in the tenth century. Leonardo da Vinci, who lived so recently as the opening of the sixteenth century (1452–1519), was one of the first Europeans to grasp the real significance of fossils, and, as we have said, it has been only within the last century and a half that man has begun the serious and sustained deciphering of these long-neglected early pages of his world's history.

§ 2

Natural Selection and the Changes of Species.

In the previous section we have had no clear definition of life. It may be well to put plainly certain general facts about this new thing which was creeping in the shallow waters and

intertidal muds of the Early Palæozoic Period, and which is, perhaps, confined to our planet alone in all the immensity of space.

Life differs from all things whatever that are without life in certain general aspects. There are the most wonderful differences among living things to-day, but all living things past and present agree in possessing *a certain power of growth*, all living things *take nourishment*, all living things *move about* as they feed and grow, though the movement may be no more than the spread of roots through the soil, or of branches in the air. Moreover, living things reproduce; they give rise to other similar living things, either by growing and then dividing, or by means of seeds or spores or eggs or other ways of producing young. *Reproduction* is a characteristic of life.

No living thing goes on living for ever. There seems to be *a limit of growth* for every kind of living thing. Among very small and simple living things, such as that microscopic blob of living matter the *Amœba*, an individual may grow and then divide completely into two new individuals, which again may divide in their turn. Many other microscopic creatures live actively for a time, grow, and then become quiet and inactive, enclose themselves in an outer covering and break up wholly into a number of still smaller things, spores, which are released and scattered and again grow into the likeness of their parent. Among more complex creatures the reproduction is not usually such simple division, though division does occur even in the case of many creatures big enough to be visible to the unassisted eye. But the rule with almost all larger beings is that the individual grows up to a certain limit of size. Then, before it becomes unwieldy, its growth declines and stops. As it reaches its full size it *matures*, it begins to produce young, which are either born alive or hatched from eggs. But all of its body does not produce young. Only a special part does that. After the individual has lived and produced offspring for some time, it ages and dies. It does so by a sort of necessity. There is a practical limit to its life as well as to its growth. These things are as true of plants as they are of animals. And they are not true of things that do not live. Non-living things, such as crystals, grow, but they have no set limits of growth or size, they *do not move of their own accord* and there is *no stir within them*. Crystals once formed may last unchanged for millions of years. There is *no reproduction* for any non-living thing.

This growth and dying and reproduction of living things leads to some very wonderful consequences. The young which

a living thing produces are, either directly or after some intermediate stages and changes (such as the change of a caterpillar into a butterfly), like the parent living thing. But they are never exactly like it or like each other. There is always a slight difference, which we speak of as *individuality*. A thousand butterflies this year may produce very many more next year; these latter will look to us almost exactly like their predecessors, but each one will have just that slight difference. It is hard for us to see individuality in butterflies, because we do not observe them very closely, but it is easy for us to see it in men. All the men and women in the world now are descended from the men and women of A.D. 1800, but not one of us now is exactly the same as one of that vanished generation. And what is true of men and butterflies is true of every sort of living thing, of plants as of animals. Every species changes all its individualities in each generation. That is as true of all the minute creatures that swarmed and reproduced and died in the Archæozoic and Proterozoic seas as it is of men to-day.

Every species of living things is continually dying, and being born again as a multitude of fresh individuals.

Consider then, what must happen to a new-born generation of living things of any species. Some of the individuals will be stronger or sturdier or better suited to succeed in life in some way than the rest, many individuals will be weaker or less suited. In particular single cases any sort of luck or accident may occur, but *on the whole* the better equipped individuals will live and grow up and reproduce themselves and the weaker will *as a rule* go under. The latter will be less able to get food, to fight their enemies and pull through. So that in each generation there is, as it were, a picking over of a species, a picking out of most of the weak or unsuitable and a preference for the strong and suitable. This process is called *Natural Selection* or the *Survival of the Fittest*, though *Survival of the Fitter* would be the more precise expression.

It follows therefore, from the fact that living things grow and breed and die, that every species, so long as the conditions under which it lives remain the same, becomes more and more perfectly fitted to those conditions in every generation.

But conditions do not remain the same and every species lives a little uneasily in its conditions. Adaptation is always imperfect and sometimes it is very imperfect. And coming to the help of life in fitting itself to the exigencies of circumstance is the fact that ever and again appear novelties in structure, sudden marked differences called *mutations*. differences much

greater than the ordinary individual difference. These mutations may be encumbrances in the struggle for life, or helps, or they may not affect an animal's chances at all. In the former case they are rejected by natural selection, in the second they are welcomed and encouraged, in the third they may spread throughout a species, unchallenged, features neither helpful nor harmful, a spontaneous change. We do not as yet know what causes mutations; we know only that life is continually experimenting in this way and that its experiments come to the sieve of natural selection for endorsement, indifference or elimination. Mutation itself seems to be an entirely haphazard process. A mutation may just hit the urgent need of the time, it may be a pointless irrelevance, or it may be an absurd variation. In the latter case it produces a "monster" which dies. In the former it spreads throughout the species. The manner of its spreading, elucidated by the Abbé Mendel, is too long a story to relate here. The reader will find it clearly explained in the *Science of Life*—now a companion work to this *Outline*.

Suppose, for example, there is some little, furry, whity-brown animal living in a bitterly cold land which is usually under snow. Such individuals as have the thickest, whitest fur will be least hurt by the cold, less seen by their enemies, and less conspicuous as they seek their prey. The fur of this species will thicken and its whiteness increase with every generation, until there is no advantage in carrying any more fur.

Imagine now a change of climate that brings warmth into the land, sweeps away the snows, makes white creatures glaringly visible during the greater part of the year and thick fur an encumbrance. Then every individual with a touch of brown in its colouring and a thinner fur will find itself at an advantage, and very white and heavy fur will be a handicap. Every favourable mutation will be seized upon and welcomed by natural selection during the ages of stress. There will be a weeding out of the white in favour of the brown in each generation. If this change of climate comes about too quickly, and no favourable mutations chance along, the species may be exterminated; but if mutations appear of a helpful kind and have time to spread themselves widely, the species, although it may have a hard time, may yet be able to change itself and adapt itself generation by generation. This change and adaptation is called the *Modification of Species*.

Perhaps this change of climate does not occur all over the lands inhabited by the species; maybe it occurs only on one side of some great arm of the sea or some great mountain