A HISTORY OF SOME SCIENTIFIC BLUNDERS

George McCready Price

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By

GEORGE McCREADY PRICE

Author of "The New Geology; a Textbook for Colleges," "The Phantom of Organic Evolution," "Evolutionary Geology and The New Catastrophism," etc.

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FOREWORD

IN the days of imperial Rome, when a victorious general was being given a triumph through the streets of the Imperial City, we are told there was always a slave stationed at the back of the conqueror, whose business it was to keep whispering into his master's ear: "*Hominem memento te;*" "Remember, you are only a man."

In our day, when natural science is being acclaimed on every side as the real Moses who has led the world out of the slavery of superstition and ignorance, it may be well for some friend of true science to remind scientific specialists that possibly not all of the greatest problems of life have yet been solved by what is arrogantly or ignorantly termed the "scientific method," which after all is only the method of enlightened common sense applied to the study of the things and the processes of nature. And I believe that one of the best methods of enabling scientific workers to keep their feet "parked" on the ground is to get them to study some of the blunders which in some cases continued to pass for proved science for a century or more, sometimes for many centuries.

This book is not an attack upon science or men of science. Why is it that so many teachers of science to-day are still troubled with a persecution complex? The world has advanced far since those days when the leaders of the French Revolution beheaded Lavoisier, the most eminent chemist of his time, because, as they said, "The Republic has no need of scientists." The solid achievements of science to-day, in harnessing the forces of the world, in making the past and the distant live in our presence, have almost reversed the situation, until, to hear some specialists talk, one might almost think that they were about to reverse this dictum, and to say that " scientists " have no need of the rest of the world.

But the friends of the further progress of science will be well advised if they set themselves against a very common tendency of our day to class mere speculation as " scientific," because forsooth it attempts to deal with subjects that may be properly termed scientific. Nothing tends more to drag the fair name of science in the dust than the annual crop of wild speculations broadcasted from the meetings of certain learned societies under the ægis of some scientific name, when every intelligent person who reads such propaganda knows that these statements are mere guessing, and are broadcasted only as support for some particular phase of the theory of man's animal origin. During the long history of the various natural sciences, we see that periods of the patient gathering of facts have always alternated with other periods of shameful speculation. It is to be hoped that we are nearing the end of the present period of wild guessing, a period that was inaugurated a little over fifty years ago with the publication of a certain book professing to deal with the origin of species. The clear and unconfused separation between facts and speculations, between things proved and things quite unprovable, was never more necessary than to-day. And the greater the triumphs of applied science the more necessary is it for us all to remember that when even the best trained men of science attempt to deal with subjects quite outside their own field, with which they have never become personally familiar and hence can only speculate upon, they always prove by their blunders that they are only human, all too human.

It is hoped that a glance at some of the blunders of the past may teach us some useful lessons for to-day. A favourite argument in defense of any popular doctrine (after its scientific defects and false logic have been pointed out) is an appeal to its present popularity. Such people may learn a useful lesson from the history of other scientific doctrines which have been just as widely accepted for an even greater length of time, but which turned out to be blunders after all. In reality, we know that there can be no finality about some of the most popular of present-day theories, when we see by analysis that, while they contain some facts, they also contain much that is pure speculation with still other large portions of what passed for "facts" a generation ago, but which are now known to have been mistakes. The future reputation of certain men connected with these theories will be determined by the way in which they relate themselves to the discovery of these mistakes. Because, as F. W. Westaway has well expressed it, "Any attempt to make facts square with a pet hypothesis is a sure and certain mark of the unscientific mind" (*Scientific Method*, p. 250).

Since the world in general accepted the theory of organic evolution about fifty years ago, it has been found that Darwin was mistaken on every one of his major theories. Yet Darwin's argument, based largely on what we now know were mistakes, was the chief reason for the world's accepting the theory of monophyletic evolution, which in Darwin's day had been before the world for several preceding generations. Darwin thought it quite useless to argue for the general idea of organic evolution until the *cause* of the transformation of species had been discovered; when he thought he had discovered this cause, he was able to convince the world of the general doctrine. The curious thing is that now the world keeps on believing the general doctrine of organic evolution, in spite of the almost universal acknowledgment among biologists that Darwin's supposed cause is in reality no cause at all.

In addition to this loss of confidence in Darwin's explanation of the "cause" of transformism, very serious flaws have recently been found in the logic of the geological argument lying back of every scheme of organic development. If these flaws in the logic of the geological outline are confirmed and recognized by the world at large (and the history of science proves that by far the most common kind of blunder has always been the blunders in logic), how long will it take for the world to outgrow the whole theory of organic evolution, just as it has already outgrown and discarded so many other widely accepted theories during the past two or three hundred years?

That there are signs all around us of an imminent collapse of the entire structure of organic evolution, cannot be denied by any one who is acquainted with the modern progress of scientific study. I need not here enumerate the various departments of natural science in which we see signs of this collapse. It is sufficient for the argument of this present volume *that such a collapse is possible,* and that there can be no intrinsic finality about any scheme of the origin of things which is and always has been at war with some of the most basic principles of philosophy and revealed religion. The Bible is an anvil which has worn out many a hammer; and the evangelical church has endured to see the fall of many a system of opposing world-knowledge which in its rise and in its brief day of popularity boasted that it constituted the sum of human wisdom.

> *"Our little systems have their day,*
> *They have their day and cease to be."*

Blessed is the man who has placed his trust, not on the fickle and necessarily incomplete and imperfect conclusions of human study and investigation, but on that living Word of God which has endured and will abide forever.

G. McC. P.

Berrien Springs,
Michigan.

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I

THE ALLEGED CONFLICT BETWEEN SCIENCE AND RELIGION

BECAUSE of the clever but superficial and biased books of H. T. Buckle, J. W. Draper, and Andrew D. White, to say nothing of the books that are more openly propagandist material for the evolution theory, many people firmly believe that there has always been a perpetual antagonism between science and religion, an eternal blood-feud, which can never cease except by the complete victory of the former in the spirit of the old limerick—

> "*There once was a lady of Niger*
> *Who went to ride with a tiger;*
> *They returned from the ride*
> *With the lady inside,*
> *And a smile on the face of the tiger.*"

More recently, other historians of science have given us quite a different picture of the progress of scientific discoveries. As examples of these may be mentioned J. T. Merz's *European Thought in the Nineteenth Century* (5 vols., 1907), R. H. Murray's *Science and Scientists in the Nineteenth Century* (1926), the first volume of George Sarton's monumental *Introduction to the History of Science,* and several volumes by Charles Singer, Lecturer on the History of Medicine in the University of London. The latter author has given us a very condensed little volume entitled: *Religion and Science, Considered in Their Historical Relations* (1928), which deals specifically with the point we are here considering.

The archæology of ancient Egypt and Babylonia gives us glimpses of a remarkable knowledge of astronomy (doubtless also accompanied by other lines of science) which prevailed at the very dawn of history; but our views are like fleeting shadows, and we know nothing of the relation between this knowledge of nature and the religions then prevailing. The real scientific idea, or a formal attempt to study and understand the world in its various aspects, was a characteristic of Greek thought; and yet the religion of the Hellenes never reached anything like the formal, rational consistency of the Hebrew religion. Accordingly, we have no complete or self-consistent cosmology from a religious point of view which has come down to us from those clever people of Attica who have given us so many other things.

Two points of conflict between Greek science and Christianity would be the theory of the eternity of matter and spontaneous generation. The idea that matter, or the stuff of which the world is composed, can never be destroyed and was never created, has come down to our day, and is still taught in most school text-books. In recent years, however, the facts connected with radioactivity have compelled the leaders of modern physics to say that many kinds of matter (possibly all kinds) are actually disintegrating before our eyes; that in fact the elements seem to be dissolving into radiation, with no known method of reversing this process. Millikan and Lodge both try to assure us that "probably," or "doubtless," the reverse process is going on somewhere away off in the abyss of space; but this hope or speculation is vigorously denied by others. The obvious conclusion, however, from this known present disintegration of matter, would be that the chemical elements, or the stuff composing the universe, must at some time in the past have been actually created. Sir J. H. Jeans, Secretary of the Royal

Society, emphatically takes this position (*Eos,* pp. 56, 52, 55; 1928).

Regarding the Greek idea of the spontaneous generation of life, we all know how utterly contrary to all our modern discoveries it is. Both the eternity of matter and the theory of spontaneous generation will be discussed more fully in later chapters of the present volume. Suffice it to say here that, in so far as Christianity was in conflict with Greek science on these two points, it now turns out that the Hebrews were right and the Greeks wrong. Perhaps some may say that it is too soon to claim a complete vindication of the Christian doctrine of the creation of matter. But it is certainly true that this doctrine has much stronger scientific support and has much more eminent scientific authority on its side than it has ever had before in the last two thousand years.

Out of the revolution in thought initiated by Socrates, arose two distinct schools of philosophy. Plato and his doctrine of " ideas " culminated in the Neoplatonic group; and the Neoplatonists certainly were not helpful to the further progress of natural science. The other group, the Epicurean, might be thought to be more naturally favourable to scientific study. But as matters turned out, both these groups exercised a depressing and hostile influence on the development of science.

Aristotle (384–322 B. C.), the pupil of Plato and the teacher of Alexander the Great, undoubtedly represents the high-water mark of natural science in the entire ancient world. Although other Greeks both before and after him taught the sun to be the center around which the earth and the planets revolve, Aristotle chose the opposite view; and although he believed the earth itself to be a sphere, he held that it is the center of the universe, the sun and all the other heavenly bodies moving around the earth with uniform velocity in various concentric circles. His system of astronomy, with essentially all that he taught about the human body and regarding plants and animals, became a fixed and unalterable system of scientific orthodoxy for about 2,000 years, or from about 350 B. C. until 1650 A. D.

It is worth while noting the reasons why scientific study stagnated and ultimately died out almost entirely. As we shall see, the spread of Christianity was certainly not the cause of this stagnation of scientific study.

Stoicism was undoubtedly the most influential system of ancient philosophic thought; but it developed into a gloomy, pantheistic fatalism, in which nature was pictured as a cruel though impersonal tyrant. In our day we think of the forces of nature as things that we can control and use for the service of mankind; but there was no such view of nature among the Stoics. The settled gloom and weariness of the world which became so nearly universal was due largely to the prevailing view of nature. They had no curiosity to know more of the cruel, tyrannical universe in which they found themselves imprisoned. Astrology came into the Greek and Roman world from the mystic East, and by means of it men sought to know the future, even though they might never hope to control it. But a settled fatalism became more and more established as the scientific and religious creed of the world. Even Astrology tended to confirm this view of the great iron, merciless universe, "awful with inevitable fates." Like a fly in amber, the "Meditations" of Marcus Aurelius (121–180 A. D.) have preserved for us a picture of the settled gloom which pervaded all that dying ancient world.

The end of that ancient civilization was not due primarily to the invasions and conquests of the northern barbarians, but to that inner decay of the spirit which is thus graphically pictured by Charles Singer:

"The Roman had forsaken his early gods, that crowd of strangely vague yet personal beings whose ceremonial propitiation in every event and circumstance had filled his fathers' lives. He had before him an alternative of the oriental cults whose gods were but mad magicians—a religion unworthy of a philosopher—and the new religion of science whose God, he now saw in his terror, worked by mechanical rule. He had abandoned the images of his ancient deities to embrace the feet of *Natura* whom he believed to be a lovelier goddess, and lo! it was a pitiless machine to which he found himself clinging. His soul recoiled and he fled into Christianity," though it must be owned that this Christianity was quite different from that original model portrayed in the gospels and the epistles of the New Testament. "Science had induced that essential pessimism which clouds the thought of the later pagan world. It was reaction against this pessimism which led to those great spiritual changes in the midst of which Antiquity went up in flames and smoke" (*Religion and Science*, p. 27).

Rome had died religiously and even intellectually before she died politically. Long after the barbarians were pounding at the gates of her capitals, she was consigning to the lions or the red-hot gridirons the noblest of her citizens. And when, as a sort of death-bed repentance, she finally accepted Christianity under Constantine, it was a form of religion already so corrupted and paganized that it possessed no renewing or regenerating power intellectually or morally.

It was Philo, of Alexandria, the contemporary of Jesus, who perhaps more than any other one man shaped the religious life of those subsequent ages which, though they are called Christian, were far more like the anti-scientific philosophy of Plato than like that sturdy, practical, commonsense view of the human body and of the natural world which we find in the New Testament as well as in the Old. Just as the Stoics had allegorized Homer, so as to make him justify their views, so Philo dealt with the Old Testament, making allegorical nonsense out of its plainest teachings. In this way the Hebrew doctrine of a real Creation by a Being above and independent of nature, who still controls and guides the universe in every detail, was twisted by Philo into a Platonic form, with a personless abstraction substituted for the Hebrew Creator, this "god-idea," as he termed it, being "without emotions, without attributes and consequently without name, changeless and imperceptible by man, self-sufficient" (Singer, *op. cit.*, p. 31). Such a colourless abstraction was so far removed from human life that a second abstraction, the *Logos*, was brought in by Philo as an intermediary between God and the world. When to these philosophic inventions was added the common pagan idea that brute Matter (called by the Greeks the "*Hyle*," and opposed to "*Nous*," which means Mind or Spirit) is the prime source of all the evil and misery of the world, we can easily recognize the fundamental cause of that revolt against reason and science which became such a characteristic attitude of succeeding ages.

Small wonder, then, that all true observational knowledge of nature had died long before the alleged triumph of Christianity under Constantine. As Singer justly remarks, this expiration of natural science "was the result of internally acting causes. In origin it had nothing to do with Christianity, which was not yet in a position to have its full effect on pagan thought" (p. 34). The Christian religion, it is true, did appear as the opponent of that philosophy of pessimism and despair which was then the reigning orthodoxy, and was called scientific. In this sense Singer admits that early Christian thought was "anti-scientific." "It is, however, essential to remember that the early Church, in developing this opposition, was not dealing with living observational science. The conflict was simply with a philosophical tradition which contained dead, non-progressive, misunderstood scientific elements" (p. 34).

The fact that for a thousand years the Western World kept milling around without scientific or intellectual progress, and that during this period and even later the Church often appealed to the Bible as authority for many erroneous ideas regarding the natural world and the nature of man himself, has often aroused the glee of agnostics and atheists. Their jubilation might have a meaning if directed against Roman Catholics, who teach that the Church never changes, and who thus must say that the teachings of the Church during even this period must be true. But such a line of argument can have little point when directed against an evangelical Protestant, who is what he is because he holds that the nominal Church of the Middle Ages was wrong in a great many respects and had to be reformed. Unfortunately, many grotesque ideas, like that of a flat earth, a crystal vault of firmament above the atmosphere, or even the extreme form of the fixity of species, are still often saddled off on the Church, when in truth such teachings can only by violent measures be attributed to that Text-book of Christianity which Protestants appeal to as a means of correcting the blunders of either theologians or men of science.

During the long night of the Middle Ages, men were not interested in making new discoveries or new observations regarding nature. They were looking backward to antiquity, back to Plato, and Aristotle, and Galen. When Thomas Aquinas (1225–1274) compiled his exhaustive *Summa Theologica*, which became the religious and intellectual guide for many succeeding centuries, he built his science and his philosophy, which embraced the entire universe and man's relationship to the universe, upon the recently recovered writings of Aristotle. Thus the astronomy, the physics, the botany, the zoölogy, even the system of human anatomy and medicine of many following generations, was crystallized around the teachings of science as known 300 B. C.: and if by chance any inquisitive spirit happened to discover any novelty in the world around him, he always tried to reconcile his unfortunate discovery with the writings of the master (Aristotle).

This attitude of mind is well illustrated by the story of a Jesuit father who thought he had anticipated Galileo in discovering spots on the sun. When he communicated his discovery to the superior officer of his Order, the latter replied: "I have read Aristotle's writings from end to end many times, and I assure you I have nowhere found anything similar to what you describe. Go, my son, and tranquillize yourself; be assured that what you take for spots on the sun are the fault of your glasses, or of your eyes" (L. T. More, *Dogma,* p. 99).

Neither the Revival of Learning nor the Reformation, at least in their earlier stages, had much influence on science. So far as the former is concerned, it was a revival of *ancient* science; its leaders had no interest in new observations or in new methods. And although Luther thundered against the philosophy of Aristotle as well as against the theology of Rome, the leaders of the Reformation showed little more sympathy with experimental science than did the Papal leaders.

Roger Bacon (1214–1294) is almost the only man during this period who valued or studied what he calls "experimental science." He did not do anything very wonderful in the way of scientific discovery; it is wonderful enough that he should be so far in advance of his age, and should be ambitious for making and teaching scientific discoveries. He had a stormy time of it with his contemporaries; but he seems to have invited trouble for himself by his jealous and censorious disposition. Regarding the idea that he was persecuted by the Church for his religious beliefs or for his science, as has been repeatedly asserted by evolutionists, Singer says:

> " It is very important for us to note that there is no trace in Roger Bacon's writings of any consciousness of opposition to religion. He thinks he is writing in support of the faith. . . . There is nothing in any of the works by him that should lead us to consider that by his contemporaries he was regarded as heretical or unorthodox in matters of religion. Since his day many legends have arisen around his name, but there is not the least historical evidence that his views were held to be subversive of religion by his contemporaries. Bacon was certainly in bad odour with the authorities of his order, but of Bacon as a heretic or as a protagonist of any war against religious belief we hear never a word " (*Religion and Science*, p. 45).

Copernicus the astronomer and Vesalius the anatomist, each published a book in 1543, " which perhaps better than any other may be regarded as the birth-year of modern science " (p. 50). But though the one of these men laid the basis of the new astronomy which was to overthrow the ancient one of Aristotle and Ptolemy, and the other prepared the way for a system of anatomy and physiology which would render the system of Galen and Hippocrates a mere historical curiosity, yet both Copernicus and Vesalius went their ways in peace unmolested by any Church officials.

In view of the storm raised in modern times over the theories of biology, it might be supposed that the sciences dealing with life would have been the first to stir up trouble with the defenders of the Church. Yet history shows that this was not the case. Down until the middle of the nineteenth century, the students of the various branches of biology had not in any way got into trouble with the Church. It was the astronomers and the physicists who felt the heavy hand of reproof. But the reasons for this state of affairs are not hard to discover. The biologists of that day were not speculating regarding the origin of things, while the astronomers were attempting to deal with problems which the Church considered to be vitally connected with religion.

Giordano Bruno (1548–1600), who was burned at the stake for heresy, cannot properly be regarded as a martyr for science. He had seized upon the novel teachings of Copernicus and had made them the ground for fantastic speculations which set him in direct opposition to some of the plainest doctrines of religion. He denied particular providence, and thus rejected miracles; taught the uselessness of prayer, and fatalistic necessity. In him we see one who had rejected all the fundamental doctrines of Christianity for an essentially pagan pantheism, and who was merely using some of the recent scientific discoveries or theories to support his religious heresy. Bruno was in no sense a scientist or a scientific discoverer, and in his death "science was not in the least involved, as Bruno was in no sense a man of science" (L. T. More, *Dogma,* p. 85).

The case of Galileo Galilei (1564–1642) seems more like a real example of a scientist who was hounded by the guardians of orthodoxy because of his scientific teachings. But a closer study of the facts may give us quite another impression.

It is quite true that he was a man of science. The originator of experimental physics, the introducer of both the microscope and the telescope to the learned world, the discoverer of spots on the sun, of the satellites of Jupiter, not to mention many other phenomena, his is one of the illustrious names in the catalogue of genuine men of science.

But he had a sharp tongue, a vitriolic pen, and was a master of a most effective literary style. Added to this was the fact that for years he occupied very prominent positions of well-paid academic leisure which he employed in castigating the follies of certain scholastic bodies. No wonder his rivals were jealous of him; nor any wonder that he tried not in the least to conciliate them. For he was closely connected with the inner circle of the Papal Court, and was not at all backward to make things very uncomfortable for certain orders, especially the Jesuits. In reality it was just a Church family quarrel between Galileo on the one side and certain influential educators on the other; and in this quarrel Galileo lost out. Says Dr. More:

> "Galileo had aroused personal enemies by incessant attacks of the most bitter sort on the Jesuits. Not content with the convincing nature of the scientific discoveries which came from his fertile mind, he used his proofs of the Copernican theory as a weapon against the dogmas of the Church, and wrote his *Dialogues* with a pen dipped in vitriol. . . . His trial was the personal reply of the Jesuits, his enemies, rather than an attack on science. And one is rather struck with the reluctance of the Popes to bring the question to an issue" (*Dogma,* p. 85).

And again:

> "The attitude of many modern writers on science is quite unjustifiable when they give the impression that the Church was persecuting an innocent and inoffensive old man. It is quite certain that Galileo intended his work to be a bitter polemic against the most cherished convictions of the world, and that he drove the authorities at Rome to action by his caustic and domineering temper, which never neglected to cover the Jesuits and the Aristotelians with ridicule" (p. 101).

Galileo's famous experiment with falling bodies, which he demonstrated from the leaning tower of Pisa in 1591, may be regarded as the beginning of modern experimental science. In the end, it would seem that Galileo's disagreeable experience did not result in any permanent setback to science.

The contemporary work of Kepler (1571–1630), the German Protestant, who toiled for many years at the mere drudgery of computation, is sufficiently remarkable; but it shows no trace of any conflict with religion. Kepler was preëminently religious, and always thanked God for the discoveries he had made, congratulating himself that he was but thinking God's thoughts after Him.

No name need detain us until we come to Immanuel Kant (1724–1804), the famous philosopher of Königsberg, Prussia. He undertook to remove any further possibility of conflict between science and religion by showing that the two deal with entirely distinct and incommensurable worlds. Religion, he said, has to do with the internal, the spirit of man; science or knowledge, on the other hand, is concerned wholly with the external world; and how can they ever have anything to do with each other? Accordingly he denied that any facts gathered from the external world can affect or have anything whatever to do with the religion of the soul.

It would take us too far afield to attempt to deal with this problem raised by Kant. I have considered it somewhat in my *Poisoning Democracy*. Here we can only say that Kant does not in any way come into this discussion of the supposed conflict between science and religion. The cosmological theory of Laplace (1749–1827), with a crude prototype of it suggested by Kant previously, may well be regarded as in conflict with the teachings of the Bible. Its history and its fate, for it is now discarded, will be considered in the next chapter. Darwin and his theories will also be considered later.

In so far as the Bible and the Church have arrayed themselves in opposition to these cosmological speculations, I think we are now sufficiently far along to be able to say that the Church deserves credit and praise for the stand which she then took. Certain it is that no evangelical Christian in this twentieth century will admit for a moment that there is or can be any real conflict between any true science and any statement or teaching of the Bible. All Christians hold that the Bible and the book of nature have each the same Author; how then can there be any possible conflict between them when correctly understood?

On the contrary, it has always been the position of the enlightened Christian that the Bible and the book of nature are complementary, each helping us to understand the other.

II

WAY-MARKS IN THE HISTORY OF ASTRONOMY

WHEN one begins to delve into the history of civilization in Egypt and Chaldea, one soon stumbles against some facts which indicate that these people were not by any means just emerging from a supposed ape-like ancestry. For instance, among the very earliest recorded accounts of Chaldean culture we find these people in possession of the regular recurrence of the various configurations of Venus and the other planets, and a knowledge of how to compute eclipses. (See *The Venus Tablets of Ammizaduga,* by Prof. Langdon and Dr. J. K. Fotheringham, 1928.) We think it remarkable that Thales of Miletus (*cir.* 640–546 B. C.) should have successfully predicted the eclipse of the sun which was observed in Asia Minor on May 28, 585 B. C. But he based his calculations on data which had been handed down from remote antiquity in Mesopotamia. The original records seem to date from 1921 B. C. (See *Nature,* June 15, 1929.)

These ancient people, some two thousand years before the Christian era, also knew the *saros,* a period of slightly over 18 years and 11 days, during which all solar and lunar eclipses repeat themselves in order. Now an eclipse of the moon is visible over about three-fifths of the earth's surface. In modern times we can get reports from all over the globe, and thus know that the eclipses predictable by the *saros* always come around on time in some part of the globe; whereas in ancient times, with their extremely limited geography, about one-third of the predicted lunar eclipses had to fail, because visible only at other places on the earth.

With solar eclipses this difficulty must have been vastly greater; for solar eclipses can be seen from only about one-fifth of the earth's circumference; hence a much larger number of solar eclipses must have seemed to skip at the localities where the ancients were doing their observing.

In my opinion, these instances of the skipping of eclipses in Babylonia make it wholly incredible that these ancient astronomers could have discovered the *saros* by any amount of observations repeated and recorded in the ordinary way. These facts, however, agree admirably with that account of the origin of mankind which says that man was created only "a little lower than the angels," and that for a time he held open communion with his Maker and with holy angels. Certainly this is the easiest way to account for the wonderful astronomical knowledge of the Babylonians, who also fixed the length of the year at 365¼ days, which is only about eleven minutes too long.

We can only surmise some of the other comprehensive knowledge of nature which these ancient men possessed; for the oblivion of a ruined civilization comes before our eyes. It is quite absurd to say, as some do, that these competent astronomers were childishly ignorant of the ordinary facts about the animals and the plants in the world around them. For those ancient observers of the heavens were no specialized freaks of culture, shut away from contact with their fellows; they got what they did during the ordinary business of a commercial and cultured age, and such a knowledge of astronomy implies a very considerable and accurate knowledge of thousands of other scientific facts which we often think mankind discovered only in very modern times. But our knowledge of what they knew is very fragmentary; we see only a few shadowy forms of primeval grandeur moving in and out, as we try to decipher a collection of clay tablets engraved three or four millenniums ago.

The next glimpse we get of scientific astronomy is when we see the early Greeks trying to guess their way through these and other mysteries of nature. We often speak of the renaissance, which followed the Middle Ages; but this was not by any means the first event of the kind in the history of the world. The Greek civilization was certainly a renaissance, as was also the Cretan period a thousand years or more preceding.

All of the Greek philosophers believed the earth to be round; and Eratosthenes (276–196 B. C.) even computed an arc of the earth's circumference from Alexandria to Syene (modern Assuan), and from this arc concluded that the total circumference was almost exactly what we now know it to be. He and Hipparchus (*cir.* 150 B. C.), who discovered the precession of the equinoxes, borrowed very extensively from the ancient Chaldeans, improving upon their computations; so that by the middle of the second century B. C. a very considerable number of accurate astronomical facts had been accumulated.

We now come to Ptolemy of Alexandria (*cir.* 150 A. D.), of whom we know almost nothing outside of his books on geography and astronomy, which were handed down throughout the Middle Ages, and like the writings of Aristotle were reverenced as a sort of scientific Bible.

As early as 500 B. C., Pythagoras had taught the earth to be a sphere suspended in space, rotating on its axis. But Aristotle rejected the latter part of this concept, and made the earth a fixed body about which the sun and stars all revolve. By an elaborate system of some two dozen concentric spheres (increased by Aristotle to over fifty), the astronomers of that time were able to compute the movements of the sun, moon, and planets quite accurately, though their system was clumsy in thought and difficult in its mathematical statement. But awkward though it was, this was the system that Ptolemy adopted, and which by his books, chiefly the *Syntaxis*, better known by its Arabian title of the *Almagest*, he passed along to successive generations.

Not until the time of Nicolaus Copernicus (1473–1543), was this system of the Ptolemaic astronomy superseded or even seriously questioned; so that it had a vogue of about fifteen centuries, or even more, if we date it from the time of Aristotle. The modern theories of geology and evolution are of mushroom growth in comparison.

But it must not be thought that the system of Ptolemy was wholly absurd. By it the movements of the heavenly bodies could be accounted for, and all the ordinary astronomical phenomena could be calculated with considerable accuracy. Even in the time of Copernicus and Kepler and Galileo, the new view of the sun as the center of the solar system could not be positively demonstrated, for no actual parallax of the stars could be observed, such a real confirmation had to wait until well along in the nineteenth century. Even by the end of the past century trustworthy computations of the distances of only about thirty or forty stars had been made. It was merely on the ground of its greater simplicity that the heliocentric view could be advocated by Copernicus and his followers.

The circular edge of the shadow of the earth thrown on the moon during an eclipse, the newly discovered method of actually circumnavigating the earth, the reproduction in the southern hemisphere of all those peculiar arctic phenomena like the midnight sun, all tended to confirm the doctrine of the sphericity of the earth. The newly invented telescope in the hands of Galileo (1564–1642) gave optical demonstration of the spherical form of the moon, and by inference the similar form of the sun and the other heavenly bodies. The discovery of the moons of Jupiter, made by Galileo in 1610, gave a great impetus to the new view of astronomy, and put additional pungency into the sarcasm of that great destroyer of ancient beliefs. Finally with Newton (1642–1727) the orderly movements of all the celestial bodies were reduced to a simple and universal law, and the modern ideas of the universe began to take possession of the civilized world. With Newton, also, disappeared the old pagan view of the eternity of the world, composed of the four "elements," earth, air, fire, and water, which had been handed down from the time of the Greeks. As Sir J. H. Jeans expresses it, "The time had now come to make a bonfire of all speculations which were unsupported either by comparison with observation or by reasoning based on natural knowledge" (*Evolution in the Light of Modern Knowledge,* p. 3).

It is a question whether the everlasting bonfire is not the destiny of even those more modern astronomical speculations which this gifted author seems to think more in accord with our modern knowledge. It seems probable that even these modern speculations would seem just as childish as the ancient ones, if we could view them from the point of view of still greater knowledge. True science does not consist of just keeping out of the clutches of our increasing knowledge.

III

THE GRINDSTONE THEORY

NEWTON'S work proved that law and order pervade the universe; and for one as reverent and religious as Newton, this law and order represented only the controlling power of the Creator and Upholder of the universe. But thousands who were otherwise minded could see in the law of universal gravitation only a confirmation of their view that the universe is a mere machine which, though perhaps started by God in the first place, is now quite capable of running itself quite independent of any external guidance or control.

The human mind seems prone to world-building. And many facts regarding the solar system seemed to point to a theory of origin for the sun and all his family. For instance, all the planets revolve around the sun in the same direction, even the hundreds of minor planets now known to us; all the major ones and most of the smaller ones have their orbits approximately in the same plane; such facts seemed to indicate some common origin. Several men of about this time began to speculate regarding some physical explanation of all these similar motions and positions. Descartes (1644), Swedenborg (1734), and Kant (1755), all tried a hand at speculating on a possible origin of the solar system which would " explain " these facts. Strictly speaking, however, not one of these men was a scientist; it remained for one who was a professional astronomer to propound a theory which held the field for about a hundred years as the one and only " scientific " explanation of how the sun and its family of globes became what and where they are. Pierre

Simon Laplace (1749–1827), who was already famous for astronomical discoveries which secured for him the title of "the Newton of France," put forth in a mere note to one of his books issued in 1796 a theory of the origin of the solar system which has since been known as the "nebular hypothesis."

Laplace assumed three things to start with; he assumed a gaseous nebula, it was already highly heated, and was already in slow rotation about a central mass which finally became the sun. In the course of its rotation, this mass of gas kept cooling and contracting, successively rings of matter peeled off and formed into planets and satellites. One of these detached rings became our earth, so he declared. Thus the earth in its primary stage was a mass of hot luminous vapour, which passed gradually into a liquid state; a solid crust formed on the outside of the glowing mass beneath the heavy, vaporous atmosphere; and after a long time the solid part became suitable for the first appearance of life.

Such was the origin of our earth, according to an allegedly "scientific" version, which was very widely held during all the early and middle part of the nineteenth century. And it is very important to remember that such was always the astronomical background in the minds of such men as Lyell and Spencer and Darwin, when they proceeded to carry the idea further and developed the subsequent evolutionary history of the earth and of the plants and animals upon it.

For it is evident that this nebular hypothesis makes an essential beginning for any system of evolution which finally is to culminate in man. Like those parts subsequently developed by Lyell and Darwin, it professes to appeal only to natural, present-acting causes and processes; hence we may term it a naturalistic scheme. Like them it has the prestige of a scientific name behind it. Like them also it was supposed to be so far removed from concrete scientific criticism as to be forever safe from refutation. But all scientific speculations are always at the mercy of new facts which may be discovered to-morrow. The nebular hypothesis had a long popular vogue because scientific men were ignorant of many important facts regarding the real structure and operation of the members of the solar system. In other words, the theory of Laplace was possible only in an age of astronomical and mathematical ignorance; it maintained its vogue only so long as this ignorance lasted; it had to be discarded when a sufficient number of facts became known. Similar remarks would apply to the schemes of Lyell and Darwin, which in reality were just the completion of the idea initiated by Laplace in 1796.

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How?

Why has the nebular hypothesis been almost universally discarded by astronomers and other well-informed scientific men, though still retaining its place in many school books? The reasons may be listed as follows:

1. There seem to be no ring-shaped solar nebulæ, like the type which Laplace had in mind.

2. If the planets had peeled off as rings and then condensed into globes, their motion would necessarily be backwards or opposite to the rotation of the mass from which they separated; which is not the case.

3. The theory demands that, as condensation proceeded, rotation must have increased; hence the central mass now remaining (the sun) should be revolving very rapidly and be much flattened. On the contrary, it rotates so slowly (once in 25 days) that its form remains almost a true sphere. Phobos, the inner satellite of Mars, makes three revolutions about its planet while the latter is rotating once, which also is quite contrary to the theory.

4. Modern astronomy has proved that the masses of the various planets, as well as the relative densities of the ring-

shaped masses from which they are supposed to have condensed, are quite out of harmony with what the Laplacian theory demands.

In addition to the objections given above, which have been pointed out by such men as Moulton, Chamberlin, and Hale, Sir J. H. Jeans has stated what he regards as "a far more deadly criticism," namely, that any stellar body which breaks up from excess of rotation "ought almost certainly to break into approximately equal masses," like the thousands of binary stars which we see all through space (*Evolution in the Light of Modern Knowledge*, p. 7; London, 1925).

Because of the various respects in which the behaviour of the solar system is inconsistent with the demands of the Laplacian hypothesis, George Ellery Hale, of the Mount Wilson Observatory, tells us that this hypothesis "must be reconstructed or abandoned." Jeans says about the same thing: "The present general opinion of astronomers is that these criticisms compel its abandonment" (*Evol.* etc., p. 7).

Prof. H. E. Gregory, of Yale, says of this hypothesis that "Its value lies not so much in its inherent probability as in the absence of a better theory. It violates the principles of thermodynamics and of celestial mechanics, and is out of accord with the present knowledge of nebulæ, planets, and satellites. Furthermore, the theory demands progressive cooling of the earth and an arrangement of rock masses amply disproved by geological evidence" (*Development of the Sciences*, p. 172).

True, we have other substitute theories, the planetesimal hypothesis of Chamberlin and Moulton, which is in many respects quite the reverse of that of Laplace; and the tidal theory, which is advocated by Jeans and others. Of the tidal theory Jeans remarks that "it is probably the only theory at present in the field against which quite insuperable objections cannot be brought" (*Evolution in the Light of Modern Knowledge,* p. 26).

According to the tidal theory, long after our sun had been thrown off from a spiral nebula, "a wandering star came so close that our sun, unable to stand the intense tidal forces generated, broke into pieces, and out of the débris our earth and moon, as well as all the other planets and their satellites, were formed" (p. 28). Both the other theories mentioned above are infinitely slow in their operation; "But the tidal disruption of a star," says Jeans, "is cataclysmic in its rapidity. Its whole duration is a matter at most of a few years, possibly only of a few months" (p. 27).

This theory is certainly not a uniformitarian theory. It can hardly be termed a naturalistic explanation of the origin of things; for such processes as it supposes are confessedly not now going on. And while, if we could have been back at the beginning and could have watched the real creation taking place, we should probably have called it an orderly and beautiful process, yet I do not consider it to be scientifically profitable to spin any more imaginary processes about the origin of things. For, as Thomas Chalmers once remarked, "We have had no experience in the making of worlds."

IV

PHLOGISTON AND CALORIC

MOST of the theories discussed in these pages, when actually believed in and not merely here on exhibition as intellectual mummies, were quite antagonistic to the Bible. That may not be the reason why they now are intellectual mummies, though it may be sufficient reason for keeping them on exhibition. Dagon was not an interesting god in himself; but when his head and hands had been removed by a miracle of Divine interference, his fate quite naturally made very interesting exhibition material of what remained. Similarly, most of the theories here on exhibition are now interesting chiefly because of the fate that has befallen them.

We have now to deal with some curious theories which never were particularly in conflict with anything sacred or divine, but which for a long time were so firmly established as scientific dogmas that they cannot well be ignored in any account of discarded scientific theories.

Theories sometimes have an ancestry, sometimes of ancient lineage. And the theory of phlogiston cannot be understood unless we go back to the times of the ancient Greeks, with the four " elements," earth, air, fire, and water, out of which four entities all the universe was supposed to be composed. The philosophers of Greece believed in a vague way that the idealized representatives of these four " elements " had certain " properties " and affinities between themselves; and because of these properties and affinities all the objects of the universe,—sun, moon, stars, and the various things on the earth,—had been generated by *chance*, or without any planning or design by any God or any supermundane Intelligence. It should, however, be mentioned in passing that Aristotle favoured the idea that there is a real purpose or design in the universe, thus providing in a vague way for a Deity; and it was probably this phase of his teachings which gave it such popularity during the Middle Ages.

This doctrine of the four "elements" held its vogue all down through the following centuries, side by side with the experiments of the alchemists, who by their hit-and-miss experiments were laying the foundations of modern chemistry. Robert Boyle, in the year 1661, published a book, *The Sceptical Chymist*, in which he sought to separate the real elementary substances from their "qualities" and their combinations. Real scientific chemistry was not yet born; for the scientists of that time had no conception of the indestructibility of matter. But Boyle's work would have done wonders in clearing away wrong ideas about many fundamental processes, if the truths he taught had not been hindered and obscured for another hundred years by a false theory which cast its baleful shadow over all chemical processes until about the time of the French Revolution.

Georg Ernst Stahl (1660–1734), one of the foremost scientists of his day, is the one who gave to the world the theory of "phlogiston," though he seems to have derived the germ of the idea from J. J. Becher, another erratic genius who lived a little before Stahl. Stahl is a good example of a prominent man of science who seems to have been wrong on almost every fundamental theory that he advocated, yet whose influence tended greatly to advance the general cause of scientific study.

Phlogiston was the name given to an inflammable "quality" or "principle" which escapes when a substance is burned. For instance, Stahl and his followers said that when a metal, like mercury, burns, phlogiston escapes, and a calx or earth remains; thus such a metal is composed of the calx plus phlogiston. But carbon they said is very rich in phlogiston; hence to regenerate the metal we must supply the missing phlogiston to the calx, by heating it with some such substance as carbon.

The theory was elaborated in detail, and the literature of the time is full of words and expressions containing this theory. Nitrogen was called "phlogisticated air," oxygen was "dephlogisticated air," while carbon dioxide was known as "fixed air." And it is really astonishing how well this grotesque theory could be made to "work" by interpreting all the ordinary chemical phenomena. It is equally surprising to note that during the vogue of this theory (which coincides roughly with the eighteenth century) the science of chemistry made great advances. Henry Cavendish, an accurate and careful experimenter, was a phlogistonist, as were also J. Black, K. W. Scheele, T. O. Bergman, and even J. Priestly, the illustrious discoverer of oxygen.

Of course, there were objectors; but they were overruled. When it was pointed out that the calx weighed more than the unburned metal, instead of less, as called for by the theory, the answer was given that phlogiston was a "principle" of levity, instead of one of weight; for what had a mere matter of weight to do when "qualities" or "principles" were being considered? It would then be pointed out how many facts this theory of phlogiston really did explain; and how could a scientific theory be wrong when it fitted so admirably these great numbers of examples? Did it not bring a beautiful unity into all the various processes of burning? How could an idea so useful and so simple be fundamentally wrong?

Says Professor J. Johnston, of Yale University:

"The phlogiston theory, despite its falsity, continued to prevail for a century, during which time it befogged the whole subject and paralyzed the advance of chemical philosophy" (*Development of the Sciences*, p. 80).

And this same author makes the following suggestive remark:

"This prevalence of a false theory, which hindered progress so greatly, leads one to wonder if some of the hypotheses now commonly accepted do not have a similar inverse relation to the real facts, as was the case with the phlogiston theory" (p. 80).

The overthrow of the phlogiston theory was dramatic, and was accomplished by the careful and intelligent use of weights and measures under the guidance of A. L. Lavoisier (1743–1794), the reformer of chemistry, who was beheaded by the leaders of the French Revolution, because, as they remarked, "The Republic has no need of scientists." Lavoisier proved that heat is unweighable; that combustion consists of oxygen being added to the burning substance, as he proved by weighing all the products of combustion. Yet in practical work the change from the old view to the new was very simple; for the formula of the addition or loss of phlogiston merely became the addition or loss of oxygen; and thus everything was easy.

Nearly another half-century was devoted to discussions about the nature of heat, and the theory of "caloric," a subtle imponderable fluid which was supposed to be given out by burning bodies and as the result of friction between two bodies. This theory of caloric also explained many phenomena, though a few could not be thus explained. Finally, with the experiments of Mayer, and Joule, and Helmholtz, and the interpretation of their results by Kelvin, we have the modern theory of heat as a "mode of motion," which also explains much but not all of the phenomena. The still more modern views about radiant energy and the quantum theory will be considered in the next chapters.

V

ACTION AT A DISTANCE

ALL mechanical movements of bodies may be classified according to their origin as due to either *pushes* or *pulls*. Those which seem to be caused directly by actual contact with some other material moving object we call pushes. These are easy to account for in a strictly common-sense material way. In addition there are other effects, some of which are physical movements, which seem to be due to the exercise of a force across empty space, with no apparent medium between. These we term pulls, while some of these effects we attribute to what we term "radiant energy." The mechanical pulls, at least, are quite inexplicable in any common-sense or materialistic way, because they involve the idea of *action at a distance,* as it is called. As will be seen presently, the phenomena of radiant energy are almost in the same category.

Our minds have no difficulty in understanding pushes; for we can see and handle the objective "cause" of the resulting movement. When Dr. Samuel Johnson kicked the stone to disprove Bishop Berkeley's theory about matter, he was demonstrating his understanding of a push. For his kick was a push; and all other pushes are of the same crass, mechanical order. The movement of one body is directly transferred to another body without loss of amount or change of direction. The traction of a body by means of a cord or a cable is really a push, not a pull in the scientific sense.

But a pull is different. Newton was not by any means the first to speak of the "force" of gravitation, though he was the first to explain a great multitude of similar phenomena as due to some omnipresent attraction between separated bodies. Even to the mind of the great Newton the idea of action at a distance was almost abhorrent, though he might like Kepler have attributed the phenomena to some invisible angel or spirit. Newton tried though in vain to explain gravitation in terms of differing pressures in an imaginary ether; but he very cautiously and very properly refrained from publishing his theory, because he said he was "not able from experiment and observation to give a satisfactory account of this medium, and the manner of its operation in producing the chief phenomena of nature." That is, he never could explain how a body can act where it is not; or how one body can reach out and pull in toward itself another body across vacant space.

Newton's followers during the next century were content to state the simple truth of the behaviour of gravitation, without attempting to explain the *how* or the *why* in terms of an imaginary transmitting medium. They frankly accepted the obvious fact of action at a distance, without attempting to invent a material explanation.

Both before and after Newton, various kinds of *ethers* were invented, sometimes for diametrically opposite reasons. To quote the words of Clerk Maxwell, as given in the ninth edition of the *Encyclopædia Britannica:* "Ethers were invented for the planets to swim in, to constitute electric atmospheres and magnetic effluvia, to convey sensations from one part of our bodies to another, and so on, till all space had been filled three or four times over with ethers."

But Maxwell himself, and Kelvin, and Faraday, no less than Huygens, and Young, and Fresnel before them, all tried their hands at inventing imaginary media for filling all space, even including those parts already occupied with material bodies, matter in their opinion being so absolutely porous that the ether could always pass through it "like the wind through a grove of trees." Some had the ether more dense than platinum, others more rigid than steel; while still others made it more elastic than the lightest gas. The result of all these wild theories was that during the middle and later part of the nineteenth century theoretical physics became little more than various forms of the science of the ether. And at the end of the century, one of the most eminent physicists of England declared in a public address that he considered physics had discovered about all there was to know; future progress in the science would be shown in making more accurate the third or fourth decimal places of the measurements already made.

All this was before the discovery of radioactivity.

There are still a few old timers who persist in believing in the ether. Lodge is one; for he could not well manage his spirits without such a constituent of the universe. Even Michelson seems to cling to the idea, even though his epoch-making experiments, which failed to detect any difference in the speed of light whether the earth is moving toward or at right angles to the source of the light, seem to have convinced almost everybody else that the ether must be a fiction.

A long array of modern men of science might be quoted who have utterly repudiated this idea of any medium for filling space and serving as the means of transmitting light or gravitation or electric or magnetic attraction. Says Sir J. H. Jeans, "Nature acts as if no such thing existed;" not one of these attractive or radiant phenomena is more easily explained by its means; even the problem of light does not make any such medium necessary.

In an editorial in *Nature,* the most authoritative journal of science in the English-speaking world, we find the following:

" The long succession of theories of the ether in the nineteenth century forms a closed chapter in the history of science. There seems little likelihood that the chapter will be reopened " (*Nature,* October 4, 1917).

But have the phenomena of the transmission of light and the attractive forces of gravitation, magnetism, and electric induction been so easily explained? Not at all; these phenomena are still as inexplicable as ever,—in fact more so; for it is the very hopelessness of explaining them in a material fashion which has led to the giving up of all hypotheses of the ether.

Thus Sir Joseph Larmor tells us: " No progress has yet been made, any more than in Newton's day, in unravelling the essential nature of gravitation " (*Nature,* Supp. p. 52; April 9, 1927).

Says Prof. E. P. Lewis:

" We do not know, nor can we ever hope to know, the mechanism of gravitation " (*Science,* November 23, 1923).

Einstein has attempted to " explain " gravitation in terms of esoteric mathematics, affirming that it is a necessary quality of curved space,—which is itself an arbitrary invention or assumption. Eddington treats Einstein's formula as a graph, which may or may not prove " useful " in " explaining " things otherwise inexplicable. For a problem is said to be explained in a scientific way when it has been stated in terms of other phenomena with which we think we are more familiar, even though the latter are themselves quite unexplained. But scientists do not seem to have got even this far in the case of gravitation.

But perhaps these pulls, these attractive phenomena, have no " mechanism " ; what then?

This would logically mean that we do have in these instances actual examples of action at a distance, or across really vacant space. And this would mean (for the Christian) that in these phenomena we have clear instances of the direct control of nature's processes by the fiat or word of the Deity. There can be no other alternative for the Christian. I suppose unbelievers will have to content themselves with being agnostics regarding the cause of such phenomena. All the attractive forces have to be regarded in the same light, such as magnetism, the so-called electric field, also cohesion, and chemical affinity. Some of our most eminent physicists are now openly saying that we have not explained any of these phenomena. Thus P. W. Bridgman, of Harvard, says that the electric field "is an invention" (*The Logic of Modern Physics,* p. 132). He also declares: "I cannot find a single physical phenomenon or a single physical operation by which evidence of the existence of the field may be obtained independent of the operations which entered the definition" (*Id.,* p. 57). This view seems to be endorsed by H. A. Lorentz and many others.

As for the means by which light is transmitted, Bridgman declares that:

"The properties of light remain incongruous and inconsistent when we try to think of them in terms of material things" (*Id.,* p. 164). "Physically it is the essence of light that it is *not* a thing that travels" (*Id.,* p. 164). "From the point of view of operations it is meaningless or trivial to ascribe physical reality to light in intermediate space, and light as a thing travelling must be recognized to be a pure invention" (p. 153).

But we may well ask here, Are not gravitation and the other phenomena here spoken of capable of exact and mathematical correlation with the other physical and chemical "forces" which we always associate with the idea of "secondary" causes?

Most certainly. And this can only mean that all the so-called "forces" of nature are only variant manifestations of the same fiat or will-action of the One whom we as Christians worship as our Father.

I think it high time that all Christians recognize these things. Scoffers and unbelievers may think and say as they please; for me it is a wonderful thing that in so many ways the very latest and most authoritative discoveries of science are helping us to see how all these phenomena of the natural world are but concrete examples of the presence and continued watch-care of the Creator and Sustainer of the universe.

VI

PERPETUAL MOTION

THE idea that a capacity to perform work can be detected in various forms, that this ability to perform work is a fixed quantity wherever found and capable of measurement, that it cannot be increased or decreased by any human means whatsoever, was perhaps the chief idea developed or discovered among the physical sciences during the nineteenth century.

This ability to do work is called *energy* by men of science, and the principle here spoken of is termed the law of the conservation of energy. It may be expressed in the terms that energy can be neither created or destroyed by any means known to mankind.

This puts energy on much the same basis as matter, or the fundamental stuff of which the universe seems to be composed. Energy seems to be the more abstract idea; yet it is just as real as matter, though recognizable only by its results. And in the last analysis, of course, energy in whatever form means for the Christian only a manifestation of God's direct working or control of His universe. That energy in this sense is capable of measurement is only what we might expect; for God is a Being of order and not of caprice. He has never had to experiment to learn how best to do a certain thing. And the fact that energy cannot be increased or diminished by any human means only reminds us that, according to the Bible, the creation of our world is a completed work, and is not going on now nor at any past period of human experience.

All this is in direct contradiction to the theory of perpetual motion. This latter notion has been a subject of debate from time immemorial. During the Middle Ages—we know not how long before—the problem of "perpetuum mobile," as it was then called, was discussed with much heat though with little light. While some denied the idea altogether, others apparently have always been found, like the fellows Barnum referred to, who have hoped against hope that they might be the lucky ones to invent a machine which would deliver more work than is put into it.

The methods adopted to attain this end are various; but usually it takes the form of utilizing the force of gravity in some fashion. A wheel is made with balls rolling between the hub and the rim in such a way that those on the up-going side roll in toward the hub, while those on the down-going side go outward to the rim. Endless devices based on modifications of this principle have been worked out; and after an expenditure of time and effort sufficient to master some worth-while project, the inventor wonders why the thing won't work as he expected it to do.

The famous wheel of the Marquis of Worcester (d. 1667) was probably of this type. It was exhibited before the King of England in the Tower of London, two foreign ambassadors and several of the English nobility being present. The wheel was 14 feet across, with forty weights of fifty pounds each. Its inventor records it as a huge success.

About the same period a German by the name of Bessler (1680–1745) had a similar wheel exhibited before the landgrave of Hesse-Cassel, which is said to have kept on going for eight weeks in a sealed room. It imposed upon a certain celebrated mathematician of the time who wrote to Sir Isaac Newton regarding the matter. Some time later, however, the inventor himself destroyed the contraption, professedly because of the impertinent curiosity of the many visitors.

A more high-brow method of attempting the same result was the claim of a certain American only a few years ago, who claimed to have a device for making liquid air, using only a part of its product to keep the machine running, the rest being so much extra. Three pounds of the liquid air would manufacture ten, thus leaving seventy per cent. of the product to do other useful work. Such a machine ought to have been a money maker. Needless to say this ingenious inventor does not rank with our Edisons and our Graham Bells.

Alessandro Volta (1745–1827), the Italian professor of physics who invented the "Voltaic pile," as it was long termed, and from whom we derive the word "volt" and all its many cognatives, seems to have believed in the principle of perpetual motion, so far as his own invention was concerned. He used to say: "The Pile is such a wonderful thing, that anything might happen" through it or because of it.

On the other hand, Newton was never fooled with any such false view of nature. He seems to have had a definite conviction that heat is a form of energy, thus anticipating by almost three hundred years the wonderful law of the conservation of energy. But at that time he had no possible means of demonstrating his idea, and so it was lost, for a matter of well-nigh three centuries.

The doctrine of caloric came in to confuse the science of the later eighteenth and early nineteenth centuries. Under this theory of caloric, heat was regarded as a sort of substance which can be transferred from one body to another, but which cannot be created or destroyed, though it may become latent or hidden. So long as this idea prevailed, there was no method of accounting for the mechanical motion which is lost by friction. Not until J. P. Joule (1818–1889) had devised many experiments to prove that a definite amount of heat is always equal to a certain amount of mechanical work, was the theory of caloric discarded.

It was on the implicit denial of the possibility of perpetual motion that Sadi Carnot (1796–1832), when only twenty-eight years of age, worked out the general principle which we now call the "second law of thermodynamics," which even to-day is regarded as one of the most important ideas in physical science. Carnot did not see all the applications of his law which have since been discovered. We now know that almost every phenomenon in the physical universe is attended by either a giving out or an absorption of heat. As was shown by Willard Gibbs some fifty years after Carnot, this law regulates every chemical reaction, as well as all the physiological processes of living things.

From all this we learn that energy is as real and measurable as a bank balance, though like the latter it is dependent only upon the fidelity or reliability of the Mind behind the mere phenomena. The ten dollar note which we receive from a bank has no intrinsic value of itself; it represents a promise on the part of the ones issuing it. Just so with what we call the "properties" of matter. These "properties" do not inhere in the substances themselves; they are only tokens or "promises to pay" issued by the Creator and Controller of the universe. The transformation of energy illustrates negotiable securities which can be passed along from one person to another without increase and without loss. And the man who thinks he can invent a machine that will deliver more energy than he puts into it is in effect a cosmic criminal; for he is like a man who thinks he can create wealth by raising a check to a higher value. Such commercial criminals are not always detected; but the cosmic criminal is always under the eye of the Great Taskmaster, as Milton terms him; and it is quite impossible to deceive Him.

VII

SCIENTIFIC FATALISM

THE Greek philosophers, who were pagans, developed a hard determinism or fatalism from their study of nature; and it was this system, under the name of Stoicism, which largely pervaded the ancient world during the early days of Christianity. The universe was indeed under law; but this law was heartless and cruel. Astrology seemed to offer an alternative; but even Astrology, while professing to reveal the future, proved utterly unable to control in any slightest degree those hard fates which the pagans of that day considered were ever watching to injure and destroy. The real alternative was Christianity, which, at least in its earliest and purest forms, revealed a Creator who was completely independent of nature and in absolute control of it, who could also be trusted to see that mercy and justice would be meted out either in this world or in the next.

During the long centuries that followed, or what we term the Middle Ages, the world almost forgot that we live in a universe governed by fixed law. The world had swung to the opposite extreme. People were well aware that the human beings with whom they were familiar were subject enough to caprice and whim. The sun and moon might be regular enough; but their representatives on earth, the pope and the emperor, were quite unpredictable. The world of spirits too, which seemed such a real world to the people of that day, was quite as full of uncertainty; what had they to learn from the world of nature all around them, so full of evil, misery, and death?

René Descartes (1596–1650) may be regarded as the first in modern times to attempt a unified and consistent scheme of the universe. He began by a resolve to doubt everything. But he realized that he could *think;* therefore he declared he had a real existence—a curious starting point, and full of forebodings for the system built thereon. Descartes seemed to save himself from stark materialism, for he continually protested his belief in the immortality of the soul and in God. Unfortunately, his system left God nothing to do, for the universe as built up by Descartes was strictly mathematical; every minutest phenomenon took place of necessity, just as the square of three is always nine. In all nature, both animate and inanimate, there was for him no purpose or final cause. Even in the human body, as taught by Harvey's recent discovery of the circulation of the blood, or from Descartes' own theory of the function of the nervous system, there was nothing possible but perpetual vortical movements in strictly mathematical fashion. To his contemporaries—and many ecclesiastics accepted his views—he seemed to incorporate and to harmonize all the recent knowledge in physics, astronomy, and biology. He talked very reverently about God in the abstract; but his theory crowded God out of his universe entirely. He was the primal "Modernist" of his day; and as he adroitly managed to keep on terms with the Catholic Church, his system spread far and lived long. But it had no more finality about it than has the "Modernism" of our time.

Baruch Spinoza (1632–1677), the excommunicated Jewish recluse, with his system of absolute pantheism, and G. W. Leibnitz (1646–1716), that prodigy of learning, with his doctrine of force (or energy) as the prime cause of natural phenomena, prepared the way for the idea of universal gravitation, as taught by Sir Isaac Newton (1642–1727). Galileo had proved that the movements of all bodies on the earth take place on fixed principles which can be mathematically stated and predicted. Newton now extended this idea to the heavenly bodies. Thus the entire universe was again under the domain of law; and this system was in the period following Newton on a far more solid foundation scientifically than had been the system taught by Descartes.

It is not necessary to quote testimony to show the preeminence of Newton as a scientific discoverer. He made other notable discoveries besides this of universal gravitation, any one of which would have made his name immortal; the combination of them all in one man places him on a pinnacle of eminence where he stands quite alone.

But Newton was no materialist. Like Galileo, he owned that he had not been able to discover any physical cause for gravitation, and he said with true scientific caution: "I form no hypotheses." He was a most humble, reverent Christian; the universe might be a huge machine; but it was being run by the One whom Newton regarded as "Our Father who art in heaven"; and he had no doubt whatever that purpose or design pervades all its phenomena.

Not immediately did the learned world realize the materialistic possibilities of this new view of universal law. But as has been so usual in the history of science, an apostle of Deism—I had almost said of Atheism—came forward, and taught the world to regard the universe as a self-running machine, with God so far in the shadow that He could be considered quite negligible. This man was Voltaire (1694–1778), who though utterly devoid of the scientific spirit, a dogmatist of the dogmatists, and though in no sense a man of science, perhaps did more than any other one person to give a permanent twist to all lines of science in the direction of materialism. To quote the words of Nordenskiöld, "Voltaire to a certain degree stands in the same relation to Newton as Haeckel does to Darwin" (*History of Biology*, p. 131). With him comes what was long called the period of Enlightenment (*die Aufklärung*); and "from his time originates the custom of citing 'natural laws' as proofs controverting the Church's traditional cosmic theory" (*Id.*, p. 131).

The discovery of the conservation of energy seemed to put the last finishing touch to this picture of a materialistic universe. Even life itself, under the clever hands of Darwin, and Haeckel, and Spencer, was treated as only a subdivision under chemistry and physics. Little wonder that by the end of the nineteenth century scientists were beginning to weep that there were no more scientific worlds to conquer, though Lord Rayleigh admitted that there was still left to them the work of correcting their measurements to the third or fourth decimal place.

With the turn of the century came radioactivity, and a new era dawned for the intellectual life of man. The old views have like the Arabs folded their tents and silently slunk away into oblivion; and although men of science are still rubbing their astonished eyes, and as yet like the one whose eyes were opened by the Great Physician they can only see men as trees walking, they have already become contrite and humble, as compared with their cocksure attitude during the middle and latter part of the nineteenth century. As Millikan expresses it, "The day has gone by when any physicist thinks that he understands the foundations of the physical universe as we thought we discovered them" a generation ago (*Evolution in Science and Religion*, p. 28).

Prof. A. S. Eddington voices the modern view as follows:

> "In the old conflict between freewill and predestination, it has seemed hitherto that physics comes down heavily on the side of predestination. . . . On the

scientific side a new situation has arisen. It is a consequence of the advent of the quantum theory that *physics is no longer pledged to a scheme of deterministic law.* Determinism has dropped out altogether in the latest formulations of theoretical physics, and it is at least open to doubt whether it will ever be brought back" (*The Nature of the Physical World,* pp. 293, 294. Italics as given by Eddington).

The great conservation laws of matter and of energy, which bulked so huge in the eyes of our predecessors, are still just as big and as important as ever; but they are now seen to be purely statistical laws, for which no strict causality can be traced. To quote again the author just mentioned:

"Whether or not there is a causal scheme at the base of atomic phenomena, modern atomic theory is not now attempting to find it; and it is making rapid progress because it no longer sets this up as a practical aim" (p. 299).

And again:

"Hitherto whenever we have thought we have detected causal marks in natural phenomena they have always proved spurious, the apparent determinism having come about in some other way. Therefore we are inclined to regard favourably the possibility that there may be no casual marks anywhere. . . . The position is that the laws governing the microscopic elements of the physical world—individual atoms, electrons, quanta—do not make definite predictions as to what the individual will do next" (p. 302).

From this study we may conclude that there is nothing in the physical sciences to give sanction to the Deistic view of the universe, and everything to impress us with the view that the great Creator of all things is also the direct Supervisor and Sustainer of the things which He has made. He has not resigned in favour of the "laws" that we humans have discovered as prevailing in the regularity and precision with which He does things. He has not even delegated His power to the electrons and the protons, the atoms and the molecules; least of all has He made any such things as the so-called "forces" of nature His vicegerents in running His universe. It is still literally true, though not in any pantheistic way, that "in Him we live, and move, and have our being" (Acts 17: 28).

But what is the quantum theory referred to above? This is not an easy idea to explain in a non-mathematical way; but to put it briefly, the *quantum* is a new unit of energy compounded with time. The *erg* is the unit of energy, the *second* is the unit of time; and a quantum represents 655×10^{-29} *erg-seconds*.

This mathematical quantity has been bobbing up in all sorts of physical experiments and calculations. It is an exceedingly minute quantity, but is in reality the minimum quantity with which radiation of all kinds is given out and also with which it is absorbed. For all kinds of radiation are given out discontinuously, also absorbed in the same discontinuous manner, the period multiplied by the amount of energy concerned being the *quantum*, which is the unit of what physicists term *action*. The quanta then are the units with which energy is transferred from one body to another, the kind of substance emitting the radiation impressing its own hall-mark upon it, but this peculiarity when multiplied by the time or period of its emission always being the same no matter what the source of the radiation, and no matter what kind of radiation it is, whether ordinary light, X-rays, gamma rays, etc. These are the facts which have tended to break down all the old theories about the waves or undulations in the ether. For fifteen years or so these facts have been before the world, and during this time the classical theories of mechanics have been used side by side with the newer theories, though each is essentially contradictory of the other.

A. S. Eddington in his playful way tries to give us a picture of the present predicament of the scientists. He hints that rather than try to " explain " the real facts, " It would probably be wiser to nail up over the door of the new quantum theory a notice, ' Structural alterations in progress —No admittance except on business,' and particularly to warn the doorkeeper to keep out prying philosophers " (*The Nature of the Physical World,* p. 211).

And yet at the imminent danger of being dubbed a "prying philosopher," I shall venture to say that in these phenomena of the quanta we seem to be within the inner sanctuary of the universe, and we find that energy is strictly mathematical in its manifestations, as was to be expected, but it does not seem to need any material entity for transferring it or conveying it from one body to another. It disappears from one body, it reappears at another; but of its existence as a real entity between these stages we have not the slightest intimation.

In view of all these phenomena,—light not a thing travelling, energy given out and absorbed in lumps or quanta, and all capable of exact correlation with gravitation and other forms of action at a distance—there is no wonder that the materialistic philosophers are passing many a sleepless night. I think I would, if I were one of them.

VIII

THE MIRAGE OF CONTINUITY

ONLY slowly are we learning that the various constituents of the universe are on distinct planes or levels; and that the laws prevailing on one level do not necessarily prevail, in fact may not exist at all, on other planes or levels. The laws of physics and chemistry do not wholly coincide with the laws governing living things. The laws of mechanics are not always (perhaps not at all) the laws of the subatomic world. Nor are the laws of terrestrial mechanics necessarily the same as those governing the mechanics of the stars. And just as the science of radioactivity has opened up an entirely new world all around us with which our forefathers were utterly unfamiliar, so do we have every reason to believe that there is also all around us a still other world of existences with which we may become acquainted by employing suitable methods. The continuity or universality of one set of laws on all these levels is only a superstition, a scientific mirage, which the scientific world has been chasing altogether too long.

We know almost nothing of the science of the ancient Babylonians beyond a glimpse or two of their astonishing knowledge of astronomy. In modern times, the world of mechanics, or the world of moving terrestrial bodies, was the first to be studied in a scientific way. Galileo taught the world its first lessons in terrestrial mechanics when he dropped his various sized balls from the top of the leaning tower of Pisa. From this as a start, and under the stern admonition that only by experiment and observation can we learn of the natural world, we have gone on to discover and invent, until now we can fly in the air above or navigate the waters below the surface of the ocean.

Living things began to attract the attention of students of science; and it was noticed that the physiology of both plants and animals seems to conform to the well-known laws of physics and chemistry. When Wöhler, in 1828, discovered how to make urea by synthesis, it was hastily assumed that nothing but chemical and physical laws control vital action. Various other organic substances have since been synthesized, and the end is not yet. The term biochemistry has been coined to designate the field on the borderline between the living and the not-living. But although the partition between the two has been wearing thin in places, it will bring only confusion of thought to say and work as if there is no such partition existing. There is probably no "life principle," as advocated by the vitalists; but there are many biologic laws which can never be equated with those of physics and chemistry. When we can manufacture life out of the not-living, it may be time enough to say that both forms of existence are on the same level.

When men began to study the sun, moon, and stars, they soon discovered that these bodies move like the bodies on the earth with which we are familiar. The siderial universe was clearly a huge mechanical contrivance; and astronomers and physicists concluded that all the laws of mechanics must apply to the movements of the stars, and that no other laws operate among them. Even to-day it is difficult for astronomers to realize that their science is anything more than the physics of the heavens. It seems quite impossible for some of them to break away from the view that many of the laws prevailing among the stars may be very different from those they have become familiar with among moving bodies, or hot luminous bodies on earth.

This misapprehension has led astronomy a merry chase for hundreds of years. The effort to account for the heat and light of the sun has led to all sorts of theories. For example, we know that the star V Puppis, which is radiating light at a rate 10,000 times as fast as our sun, would require as many tons of coal a second as would be represented by the figure 5 and twenty ciphers after it. Clearly no scheme of combustion will suffice to account for the radiation of the sun and stars. Similarly chemical action, radioactivity, and the heat developed by contraction under gravity, have all been tried and found inadequate. More recently, Jeans and others have been teaching that the annihilation of matter, by the neutralization of oppositely charged particles, may be the real source of the enormous quantity of energy so prodigally thrown out across space. This theory seems likely to prevail for a considerable time, as there seems no method known at present to check up on it and test it out.

When radioactivity was revealed, and the subatomic world was discovered, it was long a debated question whether the new studies should be classed as physics or as chemistry. Gradually they have been assigned to physics; but only very lately has it been realized that the sub-microscopic world does not by any means conform to all the laws that we have worked out for the macroscopic. But the new quantum mechanics is revealing to us so many strange phenomena that many have concluded that it only retards the further development of the new science to try to carry along in its study the whole kit of facts and theories employed in the world of terrestrial mechanics.

In our explorations in a new region of nature it may be all right, indeed quite inevitable, that we should at first attempt to explore the new region according to the rules of the game with which we are already familiar. I suppose that the first submarine divers tried to carry with them all the rules they had learned by slow experience about walking on dry land. It was the only thing they could do. But it would be folly for one who has never been fifty feet below the surface to dogmatize about what laws do or do not prevail down at the limits of human endurance under water. Similarly it is quite unscientific to assume that all the laws known to prevail on one level of existence must hold good on all other levels.

These radical changes which we have had to learn by many mistakes in trying to carry the experience gained on one level up or down onto other levels of existence, ought to be of service to us in undertaking to study the facts of morals or ethics. For there is a moral or ethical level, which has to do with our conduct toward one another here in a social world; also a still higher level of conduct in relationship to our Creator or to the universe as a whole. The latter we call the spiritual; its laws are the laws of religion; and only those who have had some experience on the level of spirituality know anything about the laws that here apply. Only those who have had a spiritual experience, who have at some time come into direct communion with our Creator and His spiritual agents, have any right to speak about the laws of this realm. For according to the analogies already considered, the ordinary laws prevailing on other levels may not apply here at all.

Says J. H. Newman:

" Morals and religion are not represented to the intelligence of the world by intimations and notices strong and obvious such as those which are the foundation of physical science. . . . Instead of being obtruded on our notice, so that we cannot overlook them, they are the dictates either of conscience or of faith. They are faint shadows and tracings, certain indeed, but delicate, fragile, and almost evanescent, which the mind recognizes at one time, not at another, discerns when it is calm, loses when it is in agitation. The reflection of sky and mountains in the lake is proof that sky and mountains are around it, but the twilight or the mist or the sudden thunderstorm hurries away the beautiful image, which leaves behind it no memorial of what it was. . . .

"How easily can we be talked out of our clearest views of duty; how does this or that moral precept crumble into nothing when we rudely handle it! How does the fear of sin pass off from us, as quickly as the glow of modesty dies away from the countenance! and then we say 'It is all superstition.' However, after a time, we look around, and then to our surprise we see, as before, the same law of duty, the same moral precepts, the same protest against sin, appearing over against us, in their old places, as if they had never been brushed away, like the Divine handwriting upon the wall at the banquet" (*Idea of a University*, pp. 513–515).

IX

SPONTANEOUS GENERATION

A SUPERSTITION may be defined as an unreasoned belief founded chiefly on the feelings; or a belief where personal feelings or wishes prevail in opposition to verifiable knowledge. On this basis, any belief in spontaneous generation which we find surviving today must be classed as a pure superstition. It may be worth while to study the history of this idea.

Among all heathen peoples, ancient or modern, a belief in this method of the origin of life has always prevailed. Ofttimes it has prevailed unthinkingly; for some peoples are at so low a level mentally that they do not recognize any problem at all regarding the origin of living things. Such is the condition of many aboriginal tribes in Africa or Australia. The ancient Greeks were on a much higher level; and so they taught the doctrine of spontaneous generation in an open, formal way, claiming that among all the lower forms of life it is a process still going on, and that all the higher forms once upon a time originated in this same manner, though now as everybody knows sheep and horses and birds all come into existence only from previously existing forms of the same kind. Consistently enough they extended their idea to include man also; and so the Greeks believed that each country was originally peopled by human beings who had sprung up spontaneously from the soil of that particular locality. They called such original inhabitants *autochthones;* and the nobles of Athens used to wear badges of golden grasshoppers as a sign that they were the autochthones of Attica.

Aristotle, like all the ancients, explicitly taught as an observed fact that fleas and other small animals arise naturally from decaying matter, that plant-lice spring from the dew which falls on plants, mosquitoes also from decaying matter, and so on. Even eels and other peculiar vertebrates originate in the same way.

With this high authority behind the idea, we may well conclude that no one questioned such natural origin of all the smaller forms of life until considerable progress had been made in first-hand study of nature and without any appeal to what the ancients had taught. But it does surprise us to learn that William Harvey (1578–1657), the illustrious discoverer of the circulation of the blood and the founder of scientific physiology, saw no great objection to this idea as applied to the smaller creatures, though he was a pioneer in teaching that all the higher forms of life come from the ovum or egg. J. B. van Helmont (1577–1644), a contemporary of Harvey, who keenly criticized Aristotle in many respects and who carried out in a strictly scientific manner some of the first biological experiments on quantitative calculations, was nevertheless a firm believer in spontaneous generation, and declared that he himself had succeeded in producing a number of mice in a vessel in which some rags and bran had been kept.

A half century later, Francesco Redi (1626–1698), who was court physician and a member of the Academy of Florence, proved that the worms found in rotting meat do not arise because of the putrefaction, but from eggs laid by the flies on the meat; for when he kept the flies away with a gauze, no worms appeared in the meat though it went on decaying. Yet even Redi continued to believe in spontaneous generation for gall-flies and intestinal parasites. That ill-fated genius, Jan Swammerdam (1637–1680), denied spontaneous generation completely, though he based his denial on theoretical grounds, denying also Harvey's dictum of all life from the egg, and holding to what became later known as the preformation theory, a theory which we shall have occasion to study in the next chapter. This preformation theory while it prevailed kept the still worse doctrine of spontaneous generation in suppression; but the latter appears in Buffon (1707–1788) and in Lamarck (1744–1829), it being quite an essential of their belief in organic evolution. All who are determined not to believe in Creation must believe in spontaneous generation.

In the meantime microscopes of considerable power had been devised, and by 1683 Anthony van Leeuwenhoek (1632–1723) had discovered the bacteria, the protozoa, yeast cells, and many other forms of minute life. He was himself wholly opposed to the theory of spontaneous generation, being convinced that all these microscopic things breed only after their own kind. But not so with others. With every increase in the knowledge of these minute forms of life the possibilities of spontaneous generation were seemingly confirmed. L. Spallanzani (1729–1799), who believed in the preformation theory, devised experiments to show that by boiling organic substances in air-tight vessels no living creatures of any kind afterwards appeared in them. Somewhat later F. Appert (d. 1840), a French chef, first put this new scientific knowledge to a practical use by preserving foods in hermetically sealed tins.

But another Frenchman discovered that the air in Appert's food-containers lacked oxygen; hence he concluded that it was the absence of oxygen which prevented the appearance of life. Other theories which had arisen in the meantime gave a new impetus to the belief in spontaneous generation. In 1836, C. C. de Latour asserted that the yeast associated with fermentation is due to organisms which can be destroyed by heating, a theory which was vigorously denied by all the leading chemists of the time, Berzelius, Wöhler, and Liebig.

Going back a little we find Erasmus Darwin (1731–1802), the grandfather of Charles Darwin, full of the ideas of spontaneous generation and organic evolution. His doggerel verse advocating these ideas was at one time quite popular. In the opening lines of his "Temple of Nature" he gives us the following:

> "*Hence without parents, by spontaneous birth,*
> *Rise the first specks of animated earth.*"

Lorenzo Oken (1776–1851) may be taken as a representative of a large group of mystic poet-philosophers who called themselves scientists, and whose wild theories during the early half of the nineteenth century had a very pernicious influence on the development of sound and sensible views in biology. Oken's notorious "*Ur-Schleim*" theory was published in 1805, or three years after the death of Erasmus Darwin. "Every organic thing," he tells us, "has arisen out of slime, and is nothing but slime in different forms. This primitive slime originated in the sea, from inorganic matter, in the course of planetary evolution. The origin of life occurred upon the shores, where water, air, and earth were joined." He calls these first bladder-like specks of slime *infusoria;* and according to him all the higher forms of life not only come from these infusoria, but are now merely modified infusoria.

Space would fail me to give any adequate idea of the wild theories of Oken, Schelling, and the other teachers of the "*Naturphilosophie*" of the early nineteenth century. It was a pantheistic scheme, in which their metaphysical "All" was conceived as a sphere; hence this spherical form, whether as the round human head or as a globular cell, represented the real archetype, the model of countless other forms. But this speculative "*Naturphilosophie*" had a wide vogue during the early decades of the nineteenth century; and it is the background of the teaching under which Lyell, and Huxley, and Wallace, and Darwin grew up. It unblushingly taught spontaneous generation as a settled fact, and constructed an entire scheme of nature in harmony with this idea.

Louis Pasteur (1822–1895) had already gained a high reputation by his discoveries in preventing or curing various diseases of domestic animals and cultivated plants, when he came into conflict with Felix A. Pouchet (1800–1872), professor at Rouen, who stood forth as the champion of the spontaneous origin of fermentation and putrefaction. The scientific duel between these two men was followed by the entire scientific world; and although at first the sympathies of many contemporaries were against him, Pasteur by his masterly experiments finally settled once for all that life can come only from preëxisting life of the same kind.

With true insight into real science, Pasteur argued from the specific character and constancy of type of the different organisms of fermentation, that they must be actual species of living things, and no mere products of chemical change. He proved that the air ordinarily swarms with the seed-forms of micro-organisms, that the air of high mountains is all but free from any such forms of life, but that whenever organic matter is sealed up free from all living things, no life appears in it.

"No," said he, "there is no circumstance known to us to-day which justifies us in affirming that microscopic organisms have come into the world without germs, without parents like themselves. Those who make this assertion have been the playthings of illusions or ill-made experiments invalidated by errors which they have not been able to appreciate or to avoid."

It was a terrific struggle that Pasteur had to put up against entrenched error and falsehood. One of his contemporaries, an influential member of the French Academy, M. Peter, was constantly urging that Pasteur's laboratory ought to be closed. The medical men of the time were openly hostile, most of the newspapers wrote insulting and scurrilous articles against him. "I did not know I had so many enemies," he mournfully exclaimed. It should be remembered that Pasteur's work of disproving spontaneous generation came long after the triumph of Darwin's theory of organic evolution; and that consistent evolutionists have always held that spontaneous generation is a "philosophic necessity" of their creed.

But before he died Pasteur saw many applications of his discovery carried out on a world-wide scale. All civilized peoples adopted his method of "pasteurizing" milk to preserve it; the old mistakes in the production of wine and beer were eliminated; immunity was obtained from chicken cholera and from the silkworm disease by methods which he proposed; finally we have our entire system of aseptic surgery and the modern precautions for avoiding infectious diseases. In addition we have all our modern methods of biology, including such entirely new sciences as bacteriology and parasiteology. People got along fairly well while they believed in spontaneous generation; but what a horrible world it would be if spontaneous generation were really true.

Yet what a fight it had been to establish the great primal truth that the origin of life is a non-natural or a supernatural process. Century after century the controversy raged. Long after the rise of modern science there were many highly educated scientists who denied this truth and openly taught the opposite. In the final battle it was practically one lone man against the entire world; for as already remarked by that time almost the entire world had accepted the evolution doctrine, and spontaneous generation was rightly regarded as a "philosophical necessity" as a start for organic evolution. Haeckel openly taught it in his books; Darwin, and Huxley, and Spencer and all their followers wished they could believe in it. Even yet, in this third decade of the twentieth century, we see it announced in the newspapers from time to time that Professor So-and-so has at last succeeded in producing life from the not-living.

But we can still declare in the words of the one who has pointed the way out of the biological wilderness: "La génération spontanée est une chimère."

X

SOME FOOLERIES ABOUT PREFORMATION

EVERY one of the common plants and animals originates from a single fertilized cell, usually of microscopic size, which is then nourished by its mother toward its independent development. But the process of fertilization, with its subsequent process of embryonic development, is the most wonderful, and on mechanistic grounds the most inexplicable, of the entire range of natural phenomena.

In the case of a bean, a lily, a maple, or any others of our familiar plants, a minute cell of pollen works its way down through the stigma, the style, and into the ovary, until it finally pierces the wall of the ovule cell. The contents of these two cells then merge completely, forming one perfect cell, which then proceeds to divide and subdivide in the ordinary manner of cell division, developing into the ripened seed.

The procedure is essentially the same in the case of a dog, an elephant, a whale, or a human being. A sperm cell of minute size makes its way, with every appearance of design or purpose, to where the ovum is awaiting it. Each of these cells has already been reduced in size and has parted with one-half of its normal number of chromosomes in the preparatory process of maturation. Design or purpose is evident in this reduction of the chromosomes, as well as in the subsequent behaviour of the sperm in seeking the ovum and uniting with it. But as it would be preposterous to credit these specks of protoplasm with intelligent design, we must conclude that they are merely automata under the direct control of a master Mind, the God of the universe. When these two mature cells unite, each with the reduced number of chromosomes, the normal number of chromosomes is restored. Thereafter the fertilized cell, which is now a new individual, proceeds to develop by dividing and subdividing, until soon certain ones of these new cells begin to specialize in making bone, or nerve, or other tissue, and thus the embryo develops into the form that it has at birth.

All living creatures, big and little, consist wholly of cells and of the structures built by cells. One of the marvels of the process of development is that the original cells of the different kinds of plants or animals are all so seemingly identical in appearance; yet each behaves so unerringly only in its own way, "after its kind," to build up a form like that of its parents.

But during the long centuries while this knowledge which we now possess was being worked out by patient observation and experiment, how many wild guesses were published to the world in the name of science, by those who were unwilling to confess ignorance, or who were too impatient to wait for the actual facts. In this field of nature study, as in all others, the curse of the science has always been reckless speculation, or hasty generalization from scanty or imperfectly understood data. In the story of the defeat of Absalom, Ahimaaz the son of Zadok persisted in running although he had no tidings ready; and nearly all the blunders of science have been due to the hasty running and telling of news that was not based on sufficiently understood facts.

Aristotle has recorded his wonder at seeing the heart beating in the egg after only about three days of incubation. William Harvey (1578–1657), who was court physician to James I. and afterwards to Charles I., who discovered and described the circulation of the blood, agreed with Aristotle in many things, for he held that the lowest forms of life arise probably by some natural process from the inorganic. But he framed the dictum that has become famous. To quote his own words: "All animals, even those that produce their young alive, including man himself, are evolved out of the egg." He had not himself detected the ova of mammals; for such a feat requires a microscope, and the scientific world of his day was as destitute of this aid to the eyesight as was Aristotle. But he was taking a long chance on theoretical principles, and happened to be right. Harvey considered the egg to be an amorphous jelly, and that the new individual grows out of this amorphous mass without its separate parts preëxisting in it.

A little later we find Leeuwenhoek (1632–1723), the Dutch optician who made so many remarkable discoveries with his simple lenses, and who was nearly always right in what he saw and believed, thinking that he detected a homunculus within the spermatozoon. From this he concluded that the sperm is the origin of the new life, needing only to be hatched, as it were, by the female. Thus started the school of the "spermists," in opposition to the teaching of the "ovists," led by Harvey, that all life comes from the egg.

But the real originator of the preformation theory was the short-lived and erratic genius, Jan Swammerdam (1637–1680), who by some very delicate technique and accurate work described the minute structures of insects while still in the larval form. He was indignant at the idea of spontaneous generation; but went to the opposite extreme, in practically denying any real generation at all: the new creature already exists in all its essential parts within the ovum of the parent, so he said.

In the year 1672, or about the time that the two early microscopists already mentioned were working in Holland, Marcello Malpighi (1628–1694), an Italian professor in Pisa and afterwards private physician to the Pope, sent in to the Royal Society of London two essays dealing with the microscopic examination of the developing egg. He is usually regarded as the founder of microscopical anatomy in both the animal and the vegetable kingdoms. Unfortunately, unknown to him some of the eggs which he studied had been slightly incubated; so of course he saw visions of the parts of the chicken already in the ovum. This mistake, coupled with that of Swammerdam, gave a seemingly firm foundation for the theory of preformation, which became the official scientific theory for more than another century following. On such slight mistakes may the entire philosophy of nations be shaped for several generations.

Caspar F. Wolff (1733–1794), in a thesis for his doctor's degree, published in 1759 a theory which made a slashing attack on the preformation theory, making a very strong and effectual argument against it, though on purely theoretical grounds and unsupported by any sufficient facts of original observation. His theory is usually called that of "epigenesis," meaning the theory that the organs grow upon and out of the embryo and are not already there in some elementary or rudimentary form. His view was essentially the same as that of Aristotle and Harvey, at least in so far as it opposed the preformation theory of Swammerdam. But Wolff's style and spirit were those of the romantic *naturphilosophie,* rather than those of exact experimental science. Hence his thesis was neglected for a long time, and only revived after the preformation theory had had another lease of life under the enthusiastic advocacy of Charles Bonnet (1720–1793), who worked the idea out in amusing and astonishing detail.

Bonnet was a wealthy lawyer of Geneva, Switzerland.

He had done some work in the line of insect biology which is of lasting value; but when only a little past thirty he became almost blind, and thereafter devoted himself to theoretical speculation in natural science and philosophy, publishing many books, one of which was translated into Italian, German, English, and Dutch. In sharp contrast with the tone of the age of Voltaire, Bonnet's writings are markedly religious; though it must be confessed that his religion is somewhat heterodox, one of his ideas being that all animals as well as man are actually immortal. Such a belief is very much more like Theosophy or Hinduism than Christianity.

Bonnet does not maintain that all the actual parts of the mature animal are already present in the germ. He merely wishes us to believe that each final organ and characteristic is potentially present in the germ, quite independent of all the other organs or characters. He was trying to combat Wolff's doctrine of epigenesis, which denied the actual presence of anything in the germ out of which the tissues and organs individually arise. Bonnet called his theory one of "evolution," or an unrolling of what was already present, not potentially but actually, in the ovum, though in the quotation which I have given from Harvey it will be seen that the word "evolved" had been used over a hundred years earlier in the sense of growth or development. But Bonnet's use of the word "evolution" was for a long time the only scientific use of the word. It is interesting to note in passing that Charles Darwin does not use this word in his *Origin of Species*.

Some of the methods used to state this preformation theory are absurd enough. For instance, Niklaas Hartsoeker (1655–1725), another Hollander who lived only a little later than Swammerdam, made some figures in which he pictures a mannikin seated within the "head" of a human spermatozoon, while others did about the same for the ovum, according to whether they took the side of the "spermists" or the "ovists."

Bonnet consistently denied that there was any real generation of offspring by parents. This seemed to him too much like a secondary creation. The only real origin that he would acknowledge was that which took place in the beginning; at that time and event all future posterity were encapsuled, as it were, in the generative organs of the first pair, whether of man or beast. According to this most extreme form of creationism, as it really was, all the living things that have ever been or are yet to be must have been actually created in the beginning by God, in the form of the germs present in the generative organs of the first pairs. In this we see a strange similarity to the "immortal germ plasm" of August Weismann (1834–1914), which is essentially the view prevailing to-day throughout the modern world of biology. Indeed, the "idioplasma" of Nägeli, the "biophors" of Weismann, the "gemules" of Darwin, and the "genes" which modern biologists assume to be the actual carriers of heredity within the chromosomes, are each and all only transcendental forms of the same idea as Bonnet set forth in 1762 in his work dealing with the doctrine of preëxistent germs. If one of these is wrong they are probably all wrong.

It would eventually become tiresome, though perhaps temporarily diverting, to trace the many curious forms and consequences developed by this theory during the century or more of its almost undisputed reign. Its popularity among English readers may be illustrated by the fact that John Wesley translated one of Bonnet's works into English and thus gave it a wide circulation.

This preformation theory may be regarded as the "orthodox" scientific view of most biologists down until well after the opening of the nineteenth century. It is very probable that the sudden popularity of the "recapitulation theory" of J. F. Meckel (1781–1833) and Fritz Müller (1821–1897), so enthusiastically adopted by Darwin and Haeckel, was largely due to the false theory of preformation which was already in the field as an intrenched orthodoxy. Meckel at least was a belated advocate of spontaneous generation; the others just mentioned would have liked to believe in it if they could; and spontaneous generation is about as far away as possible from the preformation theory.

The present vogue of the "genes" as the imaginary carriers of heredity residing in the chromosomes, proves that the preformation theory is not by any means dead. But in this third decade of the twentieth century, when even hard-headed physicists have been compelled to accept the reality of "action at a distance," when they recognize "quanta" of energy which appear at one spot and reappear at another without any material thing having travelled from the one place to the other, and when we find that all the mathematical laws of physical and chemical phenomena are not disturbed in the least by such a method of looking at these things, surely it is high time for biologists also to stop their endless speculations based on an *a priori* metaphysics which demands an objective and material entity as a "carrier" of every hereditary trait. If the Creator can conduct the astronomical and physical phenomena of His universe in strictly mathematical style without any material bridges or carriers for gravitation and all forms of radiant energy, surely it would be equally reasonable for us to say that He can look after the laws of heredity by means of the purpose-filled behaviour of the cells, even though we cannot trace any physical means for the transmission of what we are pleased to term the "hereditary" characters appearing in the offspring which resemble those of the parents.

The germ cells from which the various forms of life all start are notoriously similar in appearance and structure. Protoplasm seems to be just protoplasm wherever we find it, whether in the twig of a pine, the toe of a frog, the trunk of an elephant, or the finger of a man. And it is entirely possible that even if we could work with microscopes a thousand times more powerful than those of our laboratories, we should never be able to detect any material reasons why these bits of protoplasm behave so differently. Differently acting automata do not behave as they do because of any inherent " properties " in themselves.

Instead of a physical continuity of germ plasm carrying actual samples of the parent which must by materialistic fatality develop the child like the ancestor, God may have planned to have only a *continuity of germ responsibility* to carry over the structural traits of the parents. Why do we persist in trying to interpret all the phenomena of life in terms of mechanics? The laws of existence on the mechanical plane will never be adequate to explain all that takes place on the living plane; and a thousand phenomena among the cells can never be " explained " in mere terms of physics and chemistry.

If both you and I meet a starving man on the street, it may not make a bit of difference, so far as the *kind of food* is concerned, which of us pays for his getting a meal at the nearest restaurant, or which refuses. But our individual actions decide which is to get his thanks, and whose moral and religious ideas he will respect, perhaps imitate all the rest of his life. Contrastedly, it may make no difference in the mere *pain of the blow* which of us gives this starving man a kick or which does not; but it would certainly decide which of us is to be followed by his imprecations, and about which of us this man, perhaps all his family or his friends, can never hereafter believe anything good.

Just so, it seems to me, God may have ordained that, though the component particles of the germ cells may be essentially identical in all living forms, each shall develop only into tissues and structures similar to its parents.

This may not be a "scientific" explanation of the phenomena of heredity; certainly it is not a "mechanical" explanation. But I believe that it is about all that we are ever likely to puzzle out after all our study and our experiments. It is no denial of the true scientific method for us to recognize the limits of our method and of our capacities. And I am sure that the view suggested above is more in accord with what we know of nature in general than the prevailing mechanistic theories, which are ever trying to trace some material entity which passes from the parent to the child and carries with it all the potentialities of the child's future physical and mental development.

No; the preformation theory is not dead. But I for one refuse longer to worship at the shrine of Swammerdam and Bonnet, even though the modern form of the theory is disguised in a learned and transcendental garb.

XI

LAMARCK AND HIS VAGARIES

PICTURE to yourself a little wrinkled old man, who has lost four wives and now lives with two surviving daughters out of a total family of seven, who has been totally blind for many years; and you have a view of the Chevalier de Lamarck (1744–1829) in his old age, as he lives in poverty and obscurity in one of the poorer quarters of Paris. Yet this is the man who coined for us the word *biology*, with many other scientific terms, and who is usually credited with originating the theory of organic evolution.

He had been born of an aristocratic though poor family, being the eleventh child. He was destined for the Church, being sent to a Jesuit school; but he remained at school only until he was seventeen, when he joined the army. He had one day's war experience as an officer, thereafter resigning and being granted a pittance of a pension. Next he spent fifteen years as a literary hack in the slums of Paris, and then travelled as tutor to Buffon's young son. His next position was that of assistant in the botanical department of the royal museum. After the Revolution, when the National Convention were trying to start everything all over new, they were looking out for two zoölogists; and Lamarck, already fifty years of age, wholly self-taught, with absolutely no scientific training at all, least of all in zoölogy, was selected to take the department of Invertebrate Zoölogy. Thereafter he had a secure position, even though it did not give him a large salary. His official duties were not onerous; so he had plenty of time for his speculating and his writing.

As a systematic classifier of the invertebrates he is conceded to have done some lasting work. But during his long years as a literary hack he had written on almost every subject within the field of natural science, the quantity on any one topic being usually in inverse proportion to his knowledge. Wholly self-educated in science he was far behind his times in all those points of such subjects as chemistry and physics and natural history about which he wrote so much during his early life. But as Nordenskiöld remarks, one cannot gain any just idea of Lamarck's scientific qualifications in later years without some knowledge of what he wrote before his official appointment, because " throughout his life he firmly adhered in all essentials to the views he held in his youth " (*History of Biology,* p. 319).

A glance at some of his earlier works will show the bent of the man's mind. He starts out to reform the science of chemistry, which in his day was a well developed science. He denies Lavoisier's theory of oxidation, declares that there is no such stuff as oxygen, since no one has ever seen it; denies all chemical affinity, and declares instead that all the inorganic portions of the universe have arisen from the disintegration of living things, the world being built up on the principle of disintegration instead of chemical affinity. According to him, there are the four well-known elements of the ancients—earth, air, fire, and water—to which he adds a fifth, light. All the inorganic materials of the earth are but the disintegration products of living things, whose disintegration he proceeds to classify in a sort of evolutionary series which surely is, as Nordenskiöld remarks, " unique of its kind, beginning with blood, bile, urine, bone-substance, snail-shell, and proceeding to increasingly greater ' disintegrations' through shell-lime, marble, gypsum, to precious stones, metals, and lastly 'simple' rock-crystal," or quartz, which he says is the purest of the earths (p. 319).

Life, according to Lamarck, is a purely mechanical phenomenon; it is essentially motion and nothing else. Secretion and the other bodily functions illustrate the universal tendency of all things to disintegrate. All these grotesque fancies, which were far behind the science of the Middle Ages, Lamarck boasts he has evolved entirely by himself, "independent of any theory." We can well believe him.

In his later works, where he deals especially with zoology, he amplifies his theories regarding life. He arranges the animals on the basis of the presence or absence of certain organs, such as the legs or the wings, which he considers important from the point of view of classification but which modern zoölogists consider of quite minor importance; and on the ground of this ever-increasing specialization of these organs, Lamarck frames his theory of how they have evolved from one another. I quote Lamarck's own words, as given by Nordenskiöld, our latest and most impartial historian of the biological sciences:

> "It is not the organs," says Lamarck, "—that is to say, the form and character of the animal's bodily parts—that have given rise to its habits and peculiar properties; but, on the contrary, it is its habits and manner of life and the conditions in which its ancestors lived that has in the course of time fashioned its bodily form, its organs, and its qualities" (*History,* p. 322).

Lamarck illustrates his theory with numerous examples, the mere mention of these examples constituting his "proof" that organs and structures change with use or disuse, the changed structures being always faithfully passed along to the next generation, the new generation beginning where the older left off. Blind mice have arisen from normal ones which have lived for generations in dark caves; the toothless ant-eater has lost its teeth from habitually swallowing its food whole; wading birds have acquired their long legs from having to get their food out of the water and from holding their feathers up so as not to get them wet; swimming fowl have grown membranes between their toes because they have kept stretching out their toes during their efforts to swim in the water; the giraffe has developed his long neck and long front legs from constantly stretching up to browse off the tops of high trees.

The following is his account of the evolution of snakes: "The snakes sprang from reptiles with four extremities, but having taken up the habit of moving along the earth and concealing themselves among bushes, their bodies, owing to repeated efforts to elongate themselves and to pass out through narrow spaces, have acquired a considerable length out of all proportion to their width. Since long feet would have been very useless, and short feet would have been incapable of moving their bodies, there resulted a cessation of use of these parts, which has finally caused them totally to disappear, although they were originally part of the plan of organization of these animals" (R. H. Murray, *Science and Scientists in the Nineteenth Century,* p. 150).

Consistency is a jewel; and so Lamarck declares that if a number of children were deprived of their left eyes, and were to marry among themselves exclusively, there would eventually arise after a few generations a race of one-eyed men.

Life, to Lamarck, is a kind of subtle fluid, a kind of fire, related to heat and electricity. This life-fluid is scattered all through nature, "so that everywhere, and especially in hot countries, with their humid climate, there takes place a spontaneous production of life. Lamarck asserts that this spontaneous generation under the influence of heat, light, and electricity goes on incessantly, the lower animal forms—and even plant forms—being continually reproduced out of inanimate matter; he declares it to be probable that the fresh-water polypi freeze to death every winter and spontaneously generate again every spring" (Nordenskiöld, *History*, pp. 323, 324).

Holding to his prime theory that the organs and form of animals have arisen from exercise or from desire, he says that man's center of gravity is situated in advance of the spinal column, proving man's origin from the quadrupeds by efforts to hold himself upright. But he begins to hedge regarding the origin of man from the apes, and seeks to dodge the point. As Nordenskiöld remarks, "Lamarck apparently feared that Napoleon would not have been flattered by a genealogy based on the ourang-utan" (*History*, p. 326).

Probably all of Lamarck's scheme which has been recognized or praised by modern evolutionists was borrowed from Buffon, who had secured Lamarck's appointment at the museum in the first instance as assistant in botany, and whose son Lamarck accompanied in a tour of travel. From Buffon too he appears to have taken over bodily the theories of geology which "played an important part in leading Lamarck to evolutionary convictions" (J. W. Judd, *The Coming of Evolution*, p. 87). Even his idea that the effects of use and disuse are accumulated and passed along to the next generation comes from Buffon.

This latter idea, which is now known technically as "Lamarckism," has had a very interesting history since his day. Charles Darwin always refused to own that he had adopted this idea from Lamarck; why need he, when his own grandfather, Erasmus Darwin, had also taught it; and young Charles must have been acquainted with such speculations from his earliest years. All the same, the longer he lived the more did Charles Darwin come to depend upon this idea of the inheritance of acquired characters. I think he finally came to recognize that no theory of organic evolution can dispense with this idea.

When August Weismann made his devastating attack on this idea during the eighties of the past century, basing his argument on his demonstration of the "continuity of the germ plasm," a sort of scientific civil war was started which is only now dying down. In defense of the inheritance of acquired characters appeared many champions, though I can give space to the words of only two. Said Herbert Spencer (1820–1903): "Close contemplation of the facts impresses me more strongly than ever with the two alternatives—either there has been inheritance of acquired characters, or there has been no evolution" (*Contemporary Review,* February–March, 1893).

Ernst Haeckel (1834–1919), the apostle of monism, declares that "Belief in the inheritance of acquired characters is a necessary axiom of the monistic creed." And rather than agree with Weismann in questioning this axiom, "it would be better to accept a mysterious creation of all the species as described in the Mosaic account" (J. Arthur Thomson, *Heredity,* p. 195; third edition, 1919).

But much water has gone under London bridge since these emphatic declarations were made. To-day the open defenders of this theory are almost as scarce as the proverbial hen's teeth; the few who remain cling to the doctrine because all other theories of organic evolution have proved valueless. As T. H. Morgan expresses the situation, "Today the theory has few followers among trained investigators, but it still has a popular vogue that is widespread and vociferous" (*Critique of the Theory of Evolution,* p. 32).

In conclusion I can only say that the evolutionists have no occasion to be proud of the scientific attainments and the mental acumen of Lamarck, who is usually named as the real originator in modern times of the theory of organic evolution. The ideas which he put forward in the name of science have no kinship with those secure facts which his predecessors and his contemporaries were patiently accumulating as the foundation for all that we now know of the natural world. A literary adventurer during the best years of his life, he was pitchforked into an official position for which he was fitted neither by training nor by temperament; and his influence on the subsequent development of biology has in it both comedy and tragedy—comedy in the slavish imitation of his fooleries which the world witnessed for fully a century, and tragedy in the baleful and demoralizing effect which his doctrines had over the many succeeding generations of students of science, as they have seen his wholly worthless speculations and shamefully unscientific methods held up before them as an example by modern leaders who ought to have known better.

It is surely an encouraging proof of the inherent vitality of true science that it has been able to shake off the blighting influence of such a reckless speculator who for several generations has been pointed to as a great pioneer scientist.

XII

CHARLES DARWIN AND HIS BLUNDERS

IN order to understand the theories of Darwin, it is essential for us to understand the man, his temperament, his education and environment, and his mental limitations. Few men have been so uncritically praised for things they never did, or so blamed for things they never could have helped.

Charles Robert Darwin was born at Shrewsbury in the west of England in the year 1809, the sixth in a family of eight children. His father was a country physician, his grandfather having been that erratic Erasmus Darwin who wrote volumes of doggerel verse about "The Loves of the Plants" and other fancies, and who had propounded a theory of organic evolution based like that of Lamarck on the inheritance of acquired characters. Charles Darwin's mother was the daughter of Josiah Wedgwood, one of the *nouveau riche,* who had made a fortune at manufacturing pottery. She was a Unitarian, but had died when Charles was eight.

Young Charles was given the ordinary education of an English boarding school of those days, which consisted almost entirely of Latin and Greek. He tells us that he did not get much good from this sort of training, as never throughout his life did he take any interest in learning languages. Late in life he also tells us: "So poor in one sense is my memory, that I have never been able to remember for more than a few days a single date or a line of poetry" (*Charles Darwin, His Life,* etc., Edited by His Son, Francis Darwin, p. 51; 1892).

His father recognized that the boy was getting no good at the boarding school; so he took him away at the age of sixteen and sent him to Edinburgh to study medicine. Here the lectures bored or disgusted him; he never practised dissection on his own account; he attended two operations, but fled from each before it was completed. His total lack of experience in dissection and his entire ignorance of how to draw persisted through life, and rendered his voluminous zoölogical notes and collections made during the voyage of the *Beagle* quite valueless. He attended lectures on zoölogy and geology during the two years that he spent at Edinburgh—doing almost anything and everything except the study of medicine. He tells us himself that he was assured that his parents would leave him enough money to live on without his needing to practise, so he saw no need of applying himself.

His father again recognized that the young man was on the wrong track. He removed him from Edinburgh and sent him to Cambridge to prepare him for becoming a clergyman. As the son had never opened a book of Latin or Greek for over two years, he found to his dismay that he had forgotten almost everything of these languages, including even a few of the Greek letters. So he worked with a private tutor, which delayed him several months, so that he went to the University only after the Christmas vacation, early in 1828. He tells us that his time was quite wasted at Cambridge, as mathemathics " was repugnant " to him, and he again had to have a private tutor to work up what little algebra was demanded. He read the required amount of the classics, covered a little Euclid and algebra, and read quite carefully Paley's *Evidences of Christianity* and his *Natural Theology,* which were standard theological works of those days. It is interesting to remember in this connection that Paley wrote his *Natural Theology* expressly to counteract the influence of Erasmus Darwin's *Zoonomia.* In accord with the very lax standards of scholarship of those days at the English universities, Darwin was graduated in 1831, his name standing tenth in the list of those who got a mere passing grade. But on account of his having entered the university late in his first year, he was obliged to keep two more terms after passing his finals early in 1831, and spent most of this time studying geology under Sedgwick, a subject in which he had already been keenly interested, as it accorded well with his fondness for sport and hunting.

Instead of becoming a clergyman, he accepted an offer to go on the ship *Beagle* on a long voyage to the southern hemisphere. He was to pay most of his own expenses, on condition that he should have what he collected; so his time was his own to spend as he saw fit. The voyage lasted about five years; and we can well understand that young Darwin, now almost twenty-three years of age, so fond of hunting and collecting in a happy-go-lucky fashion, was able to enjoy every hour of the long periods during which the ship was in port; the result being that he saw a good deal of the various parts of South America, Australia, and the Southern Seas. He had taken with him the first volume of Lyell's *Principles of Geology,* and the geology of the countries he visited became his chief interest, so far as a young fellow in his early twenties, with essentially no scientific education, could study such a subject alone.

He sent home many collections of natural history objects, and brought with him many more. On returning to England he soon found that from a scientific point of view his profuse zoölogical and botanical notes and collections were quite useless; he gave away all his biological specimens, and devoted the next ten years to arranging and writing up his geological and geographical materials. In

1839 he married his cousin, Hannah Wedgwood, who also had some money; together they found themselves quite comfortably off; so that Darwin was able to spend the rest of his life as a country gentleman of scientific tastes, turning out book after book on various topics of natural science. He never again left Great Britain, not even for the Continent; and died at Down, a small village in Kent, in 1882, and was buried in Westminster Abbey.

So much for the bare outline of his life. He tells us that he had become a "convinced evolutionist" by 1837, when he was 28 years old, and "could not avoid the belief that man must come under the same law" (J. W. Judd, *The Coming of Evolution,* p. 142). This need not surprise us, considering the views of his grandfather, considering also that spontaneous generation was still believed in by so many, and that evolutionary views were in the air all around him. Yet considering his very slender intellectual equipment at this age, especially his utter lack of any systematic or comprehensive knowledge of science, one would scarcely suppose that he was prepared to reform the world's views of nature except by the sheerest accident. But he tells us that he thought it "almost useless" to try to prove the general doctrine of evolution until some real *cause* of the transformation of species could be made out. In October 1838, he happened to read Malthus's *On Population;* and the idea flashed on his mind that the constant struggle for existence among all forms of life would result in the preservation of those kinds adapted to their environment, and the destruction of those not so well adapted. Assuming unlimited variations in all possible directions (an assumption that did not seem so unreasonable at that day), he thought he had here the key to the indefinite modification of all living things. Unlimited variations, plus the assumed tendency to adapt themselves to their surroundings, plus the stern elimination of all forms not thus adapted —here he thought he had a full and sufficient explanation of all the diverse varieties of plant and animal life in the entire world. The rest of his career was largely devoted to expanding and illustrating this theory from every department of organic life.

But he kept the idea to himself for some twenty years, only publishing his *Origin of Species* in 1859. Meantime he had won a reputation by various works on natural history, based chiefly on the results of his observations during his voyage with the *Beagle.* Thus he was already a fairly well-known naturalist when he came forward with his theory of the origin of species. As we shall see in subsequent chapters, the situation then prevailing in geology and the biological sciences seemed to demand some sort of evolutionary explanation; and if he had not suggested an acceptable theory some one else undoubtedly would have done so. The instant acceptance of Darwin's theory by many eminent men of science, coupled with its violent and often uncritical denunciation by others in high position, created a lively controversy with great advertising value, which created a wide sale for the *Origin* and for all subsequent works by the same author. He himself kept aloof from all public controversy, but his cause was vigorously championed by Huxley and Haeckel and a host of less well-known men, so that when he died in 1882 he was the most praised, the most hated, and the least understood man in the entire scientific world.

Nordenskiöld has well pointed out the direct contrast between the methods of Darwin and those of Gregor Mendel (1822–1884), who was contemporaneously carrying out experiments with the same object of solving the problem of the origin of species. In such a comparison, says this candid historian of the biological sciences, " the English scientist naturally gets left hopelessly behind" (*History*, p. 469). Mendel starts with a few simple and easily understood characters, and studies their reappearance in successive generations singly or in combination; "Darwin, on the other hand, starts from the ideas of species and variety—that is, from the most abstract terms in biology and the most difficult to define. In fact, in this starting-point lies the whole weakness of Darwin's research work and speculation" (*Id.*, p. 469).

Darwin never realized it, but he was in reality building his entire theory around the most abstract and metaphysical ideas in the entire range of the biological sciences. Yet he has told us over and over again that he never could follow an abstract line of reasoning, and that his mind was incapable of such a method of thought. Yet here we find him starting "from the most abstract terms in biology and the most difficult to define," and carrying out a line of reasoning of the sheerest abstract nature about the origin of all living things, with a number of other little abstract terms, like "heredity," and "variation," and "natural selection," brought in to facilitate his logic. How could he fail to blunder helplessly, and by the very success of his blundering lead the entire world far afield.

The simple truth is—and it must be faced and acknowledged—that Darwin's was not in any sense a great mind. It was of that slow, lumbering type so characteristic of the average hunting and sporting country squire of England, fond of horses and dogs and shooting. When directed toward science it becomes the laborious collector and compiler and systematist, often attempting to grapple with problems of abstract logic, but floundering around in hopeless circles of its own construction. Such minds always dwell with inordinate fondness and persistence on any abstract idea which they think is their very own, something that has come to them as an intuition; as is illustrated by Darwin's pathetic devotion to his absurd idea of *pangenesis*, as L. T. More remarks, "with the blind affection of a parent for a defective child" (*Dogma*, p. 200). It was his brain-child, and he loved it; why should others persist in pointing out logical defects in it when he could see none?

As Nordenskiöld well remarks, Darwin had only a "dilettante conception of nature," thinking it his business in life to solve all the problems of existence, offering a naïve theory for everything in the organic world. Speaking of his theory of pangenesis, this author remarks: "Darwin is here, as so often elsewhere, a speculative natural philosopher, not a natural scientist" (*History*, pp. 466, 473). No man can be regarded as great in the study of nature who does not recognize both the laws of the human mind and the very definite limitations of human knowledge. Darwin understood neither. Compared with such men as Leibnitz, Newton, Cuvier, Agassiz, Helmholtz, Virchow, Pasteur, and a host of others who might be mentioned, Darwin was never more than a prattling schoolboy.

He had an amiable, trusting disposition, like an unsophisticated child. He had absolutely no critical faculty; as he himself tells us: "A paper or book, when first read, generally excites my admiration, and it is only after considerable reflection that I perceive the weak points" (*Charles Darwin*, p. 51). What an everlasting pity, then, that he did not wait a while and read Malthus over and over again, if need be, in order to see the shallow, childish arguments of that slip-shod thinker.

Aside from his prime mistake in attempting to solve all the problems of nature by metaphysical reasoning from an abstract starting-point, Darwin's greatest blunder was due to his misplaced confidence in the doctrines of Lyell. The latter was some twelve years his senior; he had already attained a very notable literary and scientific reputation before Darwin returned from his travels; for years Darwin was closely associated with him in the work of the Geological Society, and witnessed the gradual but the complete triumph of Lyell's uniformitarianism over the catastrophism of Cuvier, and Buckland, and Murchison. Why was he not absolutely safe in taking over uncritically this uniformitarianism, and extending the idea so as to include the inorganic world? Huxley has told us that for him as for many others Lyell was the chief agent in smoothing the road for Darwin; because consistent uniformitarianism postulates evolution as much in the organic as in the inorganic world.

Some Continental scholars, who have been able to see contemporary English thought with a longer perspective and hence with less distorted vision than the English themselves, have pointed out that Darwinism at its birth was greatly aided by the vogue of optimistic liberalism then prevailing, a widespread belief in the continued progress of the human race which had its home in England, having grown up out of the great technical and material progress and prosperity attendant upon the industrial revolution. This idea of inherent progress led all liberalism to hail Darwinism with delight; the religious skeptics were charmed with its apparently conclusive arguments against the doctrine of creation and its apparent demonstration of materialism. "The deficiencies in Darwin's work were therefore readily overlooked—his vague starting-point, his uncritical material, his weak arguments based on loose assumptions, his belief in the power of chance and of finality as an explanation of nature" (Nordenskiöld, *History*, p. 478).

But questions of science, like apples, have to take time to ripen. Only when such questions are ripe can the harvest be gathered. The world had first to learn the truths of the real permanency of organic types, as developed by Mendelism; next it has had to see the failure of Lyell's uniformity, and to see that a catastrophic view of geology solves most of the puzzles raised by the blundering theory of successive ages and "index fossils." So in our day, with all this added experience, we now see that Darwin was utterly wrong in every major theory that he propounded.

Perhaps his enticing theories were necessary to excite a world-wide popular interest in the problems of origins. Perhaps they were the only means to induce the scientific world to enter upon that detailed examination of the problem of origins without which we might never have been able to appreciate the crying voice of every organic form, "In the beginning God created." Perhaps without the blunder of Darwinism the modern world would have had no adequate appreciation of the great truth of a literal Creation.

XIII

A BLIND LEADER OF THE BLIND

IT may prove interesting and instructive to consider the career of Ernst Heinrich Haeckel, who may without doubt be regarded as the most influential opponent of Christianity during the latter part of the nineteenth century.

Haeckel was born at Potsdam in 1834, the son of a civil servant. He received the ordinary preparatory education of the gymnasium, and was then sent to Würzburg to study medicine. There he had two years under the eminent scientists Kölliker and Virchow, after which he spent one year at Berlin University, where he came under the dominating influence of Johannes Müller, that great teacher of teachers. Haeckel was for a time assistant to Virchow, then went to the Mediterranean, where he did some original work on Radiolaria and other marine animals. He was called to the chair of zoölogy at Jena in 1862, where he remained until his resignation in 1909. After another ten years of literary activity he died in 1919.

Such in brief outline is the life of one who used his scientific position and reputation chiefly as a means of broadcasting his monistic materialism, and who has probably excited more violent feelings and been the occasion of more heated disputes than any other student of natural science, not even excepting Charles Darwin. As Nordenskiöld states the case: "It is not at all easy to grasp the true value of his life's work. No important scientific discovery attaches to his name, and the ideas he promulgated were largely borrowed from others. The works that once brought him fame are now hopelessly out of date, but it must be admitted that much in them has now been incorporated in our general knowledge" (*History*, p. 506).

In his undergraduate days at the gymnasium he read Greek poetry, and even in his later life he was fond of showing off his classical accomplishments. During his university days he was always a well-conducted young man—no duels or drinking bouts for him, he attended strictly to his duties as a student, and went regularly to church. His letters to his parents during this period express the sentiments of a good Lutheran, and indeed are quite religious in tone. He is indignant at the strong Catholic propaganda which was carried on at the German university centers during the years following the upheaval of 1848; and he also expresses his anger at Karl Vogt and the other "materialists" of the time. In later years, his opponents had the opportunity of using some of his own arguments against him, quoting Haeckel against Haeckel with considerable effect.

During his Italian journey, he wrote letters of a different tone. He had now become a free-thinker; his former devotion to Christianity had been replaced by devotion to culture and a Comte-like worship of humanity. Dr. Nordenskiöld thinks that his free-thinking in religious matters was brought about by his liberal views in politics; for at this time the Church in Germany and in most Continental countries was obstinately reactionary and opposed to all social and political reforms.

Haeckel was always keenly interested in social and political matters, though after the unification of the German peoples under Bismarck, and the severe disappointment of the liberals at sight of the way in which this unification helped to play into the hands of the princes and the junkers, he did not take any active part in politics. After his adoption of Darwin's explanation of the origin of species, he threw his whole soul into the conflict with the conservative forces in the social as well as in the religious sphere, using the Darwinian theory of evolution as his chief weapon. In many of the German states similar-minded teachers and writers were deposed from any government positions which they held; but the rulers in Weimar (under whose jurisdiction Jena University was situated) were liberal in their views; and under their tolerance or protection Haeckel maintained his post at Jena, using the prestige of his official position for half a century as a platform from which to proclaim his radical views regarding philosophy, religion, and social conditions.

During his undergraduate days at Würzburg, his father had made him a present of a compound microscope, and it was as a student of microscopic marine forms that he did essentially all of his real scientific work. His naming and classifying of several hundred kinds of the Radiolaria is regarded as his best achievement; though since his day our knowledge of these deep-sea creatures has greatly advanced, and his work has been improved by others. He tried to reorganize the study of the sponges along Darwinian lines; but his efforts in this direction are now regarded as having many "curious features," his system of classification is declared to be "decidedly artificial," and "has proved unsuccessful and has failed to gain the acceptance of more recent systematists"; so that, though he had boldly attempted to dispense with such terms as genus and species *a la Darwin*, "in his own later systematic works he himself uses the old traditional terms of genus and species, in spite of all the assurances of Darwinism" that there never ought to be any such distinctions in real nature (*History*, pp. 509, 510).

Haeckel's work on the medusæ is said to be "in part of some value," though some of his diagnoses of species are "full of serious mistakes," for the reason that "careful detailed examination was never his strong point" (*Id.*, p. 510). Certain other one-celled organisms, related to the common Amœba, were grouped by Haeckel under the order *Monera,* and were used by him as the foundation for some of his most characteristic theories. He declared that these creatures had no nucleus; thus he found these supposedly simple un-nucleated specks of protoplasm all important in his theory, as a transition from the not-living to the living.

"Nevertheless, the improved microscopy of modern times has actually discovered in the majority of these a nuclear substance, either in the form of a single nucleus or divided into minute particles, and modern biology, which has learnt by experience to count the nuclear substance among the essential components in a cell capable of life, has in general presupposed the existence of the nucleus even in cells in which, owing to its minimal dimensions or indistinct cell-content, it has not been possible to confirm its existence. Haeckel, however, stubbornly held to his non-nuclear Monera, the existence of which he regarded as an essential qualification of that spontaneous generation by which he believed life to have arisen, and which he looked upon as 'a logical postulate for philosophical natural science'" (*History of Biology,* p. 510).

Many evolutionists besides Pouchet, the opponent of Pasteur, have felt that spontaneous generation is a "philosophical necessity" of their creed. It will be remembered how even Huxley declared that if he could look back beyond the limits of geologically recorded time, he would expect to see life appearing directly from the not-living "under forms of great simplicity." Such transition forms Haeckel thought he had discovered in his *Monera,* and he made them one of the essential parts of his entire system. In a later chapter our historian of the biological sciences again refers to this idea of the supposed simplicity of structure of these microscopic creatures.

"The Darwinists of the earlier school, chiefly Haeckel, largely interested themselves . . . in the very lowest animal forms; it was expected that they would produce fresh ideas in regard to the origin of life upon the earth, discoveries that would fill the gap between living and lifeless substance and would thus make the great evolutional series in the universe entirely uniform. These expectations, however, whether associated with Huxley's bathybius slime * or with Haeckel's Monera, have not been fulfilled; bathybius turned out to be a lifeless calcareous deposit; and in the Monera have been found nuclei and other organic details giving evidence of ordinary cell-structure. Indeed, the cellular structures of these lowest organisms have proved to be highly complex, in many of them competing with the fundamental elements of the highest organisms" (*History,* pp. 544, 545).

In a sensational speech before a scientific congress in 1863, Haeckel announced his adoption of Darwin's theory, also showing his political radicalism at a critical moment in the struggle between Bismarck and the liberals, the political situation serving as good advertising for Haeckel's philosophical and anti-religious views. This speech praised Oken, of "*Ur-Schleim*" fame, also other leaders in the romantic, dilettante "*Naturphilosophie*" of the early nineteenth cen-

* NOTE.—This is an allusion to a slimy substance which was at one time supposed to exist at the bottom of the ocean and to consist of undifferentiated protoplasm. About 1868 Huxley named it *Bathybius haeckelii,* but it was afterwards found to be merely a product of clumsy manipulation in the laboratory, being produced by alcohol in sea water, a flocculent precipitate of gypsum. See *Encyclopædia Britannica,* Vol. 3: p. 521; eleventh edition. Huxley ultimately acknowledged his mistake.

tury, as being precursors of Darwin. Indeed, Haeckel's temperament showed him to be a romantic speculator in philosophical and quasi-scientific matters, not a man of science in the modern sense of the word. This is brought out in "his utter incapacity to grasp the relativity and limitations of human knowledge" (*History*, p. 511). "Haeckel's way of constantly trying to solve the 'riddles of the universe' is far more reminiscent of Schelling than of the contemporary positivist trend of thought, just as his overbearing self-confidence and his abusive polemics are more representative of romanticism than of exact research" (p. 511).

Haeckel made liberal use of the speculations of Goethe; and the worthless scientific theories of the latter have only been saved from deserved criticism by their author's literary reputation. Indeed, the pernicious influence of Goethe's pseudo-science is partly responsible for the prolonged vogue of the mystical, pantheistic nature-philosophy of which Haeckel should be regarded as one of the last representatives. His materialistic monism, or mechanical atheism, was always his chief interest; his scientific writings were merely illustrative arguments; and his absorbing interest in Darwinism and his extravagant praise of it was due to the fact that he recognized in Darwin's book an "Anti-Genesis" which he could use to drive home his philosophy.

Regarding his notorious genealogical tree, supposed to show the pedigree of man, we are told that "Haeckel has certainly had to endure a good deal of chaff for his genealogical trees, and they will not, of course, bear too close examination" (p. 515).

After his *Generelle Morphologie,* which he regarded as his chief speculative work, he issued many other books in a more popular style, in which he emphasized his well-known "biogenetic principle," which henceforth became one of his chief arguments. This idea, that the embryo of the higher forms recapitulates or repeats in a shortened fashion the various stages through which its ancestors had passed during long periods of evolution, seems to have been first suggested (in a somewhat crude form) by J. F. Meckel (1781–1833), but was expounded by Fritz Müller (1821–1897) in a paper entitled "Für Darwin," which appeared in 1864, and immediately enlisted the enthusiastic zeal of Haeckel. Of the latter's use of this idea Nordenskiöld says:

"Haeckel was never a specialist in embryology and its points of detail were of no interest to him in themselves, but only in so far as they could serve as evidence to prove the descent of man. His ideas of embryology could in such circumstances only be one-sided and deficient; the professional embryologists offered serious objections to them, which he either affected to overlook or else answered with personal abuse. Complaints were made especially against his illustrations, which, contrary to usual practice, he hardly ever borrowed from monographs on the subject, but drew himself. Being designed exclusively to prove one single assertion, his illustrations were naturally extremely schematic and without a trace of scientific value, sometimes indeed so far divergent from the actual facts as to cause him to be accused of deliberate falsification—an accusation that a knowledge of his character would have at once refuted" (*History*, p. 517).

Appended to this last statement as a footnote our author gives us the following facts:

"It is nevertheless difficult to understand such an action as this: allowing in his *Natürliche Schöpfungsgeschichte* (ed. i, p. 242) the same clinché, reproduced three times, to represent an egg of a man, an ape, and a dog. This absurdity was removed from subsequent editions, albeit only after Haeckel had rewarded with abuse those who pointed out the fact; and the incident was for ever afterwards a theme on which his enemies constantly harped."

The curious reader who desires to pursue this rather unsavoury subject further may consult a small work of 100 pages entitled: *Haeckel's Frauds and Forgeries,* by J. Assmuth and E. R. Hull, issued in 1915 by the Examiner Press, Bombay, India.

Two important details of Haeckel's doctrine of the "biogenetic principle" are the theory of the three germinal layers and the *gastræa* theory. Space will not permit me to go into a detailed explanation of these rather technical ideas. I must content myself with reproducing at some length Dr. Nordenskiöld's comments:

"This evolutional theory is undeniably Haeckel's most brilliant and most important contribution to the history of biology. O. Hertwig was right in saying that for fifty years biological literature was under the influence of this idea; the abundant facts that were amassed on the subject of embryology during this period were mostly intended to confirm the biogenetic principle or the 'recapitulation' theory, as it has also been called, and biologists strained every effort to apply it to every detail in the development of the embryo. And the application was 'strained' in the fullest sense of the word.

"Haeckel knew from the outset that the gastrula stage of the mammals is not formed through invagination, as the theory claimed, but through delamination, or splitting off; he consoled himself, however, with the thought that in the lancet-fish invagination generally takes place, and from this primitive animal he derives the Mammalia, with the assertion that their gastrula form is due to later adaptation—to the 'falsification' of documents, of which Fritz Müller had spoken. He also explains a number of other facts of a similar kind according to the same method.

"Matters became still worse when the embryologist [Wilhelm] His came forward with an attempt to explain the entire cause of embryonic development on purely mechanical [or physiological] grounds. Haeckel was furious and replied with a shower of abuse, quite forgetting all his own utterances, in which he insisted upon a mechanical explanation of nature. In reality this mechanical, or, in other words, physiological, side of embryonic development is of very great importance, though Haeckel quite overlooked the fact in his anxiety to explain natural creation; later on, however, it received all the greater attention.

"But, even apart from this, time has dealt hardly with Haeckel's ontogenetical theories. The gastrula formation by means of invagination has proved far less general than Haeckel believed—*inter alia,* it is lacking in most of the Coelenterata—and the far-fetched homologization of the germinal layers has been considerably restricted, the same organs in a number of different animal forms having been found to possess an entirely different origin. In particular, the mesodermal formation has now been resolved into a number of different processes. In fact, the entire 'biogenetic principle' is nowadays severely challenged, even as a hypothesis; in the vegetable kingdom it has received no confirmation, which is indeed strange for a theory proposed to hold good as a general explanation of life, but even those zoölogists who in general give any support at all to the recapitulation theory do so with considerable reservations, called for by the results of modern hereditary research and experimental biology" (*History*, pp. 518, 519).

Such is the language of the candid historian of biology. Wilhelm His (1831–1904) the Swiss embryologist, later professor at Leipzig, mentioned in the foregoing quotation, has given us the following common-sense remarks about the developing embryo:

"In the entire series of forms which a developing organism runs through, each form is the necessary antecedent step of the following. If the embryo is to reach the complicated end-forms, it must pass, step by step, through the simpler ones. Each step of the series is the physiological consequence of the preceding stage and the necessary condition of the following" (Quoted by T. H. Morgan, *Evolution and Adaptation*, p. 71).

More and more as he grew older Haeckel gave himself over to reckless theorizing. He no longer made any attempt to adhere to strictly scientific methods; "Energy and soul are now consistently identified, and are generally denoted by the term 'energy,' in a manner which testifies to his absolute contempt for the simplest grounds of physics" (Nordenskiöld, *History*, p. 519).

Imaginary molecules of living matter are invented and called "plastidules," which are if possible more absurdly unscientific than Darwin's notorious "pangenes." He imitates Goethe in attributing memory to the atoms, an idea that reminds us of Erasmus Darwin's *Loves of the Plants*. But in such romancing Haeckel was cutting himself entirely away from sober science and facts, and in this state of philosophic and mental chaos he remained for the rest of his life.

His theories had been popular for a long time, and directly or indirectly had served to stimulate research. But the march of natural science was something much bigger than Haeckel and his theories. Ultimately the younger investigators discovered hosts of facts which brought confusion to the biogenetic principle, the gastræa theory, and Haeckel's other so-called "natural laws." He was surprised and bitterly disappointed. He had no taste and little experience in the minute study of detail required by the new developments; he was soon lost among the profusion of discoveries.

The special research workers seemed to lose all interest in Haeckel's pet theories, which angered him still more. He could not control the developments of the science with which he had once been connected; and he could not keep quiet, although he was now a very old man. "And so he continued the struggle on behalf of his natural philosophy, becoming, as the years went on, more and more isolated from his old friends and disciples in the world of science" (*History,* p. 523).

Die Welträtsel (issued in English under the title *The Riddle of the Universe*) appeared in 1899, and had an extraordinary circulation. From the "scientific point of view it must be regarded as utterly valueless" (p. 524). Another eminent German scientist has declared that this book fairly "drips with superficiality." And yet I suppose it is still being circulated in its various translations among the callow students of China, or Japan, or Russia, or Turkey as the full flower of Occidental civilization and the results of modern science.

His last years make sad reading. With nearly a hundred other "intellectuals" he signed a silly manifesto designed to vindicate the beleagured Fatherland in the eyes of the outside world; it really had the opposite effect. More and more he resented the way in which other scientists accused him of various unethical methods; as a protest against it all he publicly withdrew from the Established Church,—that Church which he had spent a lifetime in denouncing and fighting in every conceivable way. Finally, when well over eighty, an accident hastened the end, perhaps mercifully saving him from the infirmities of extreme age and the misery of realizing more and more that the world had outgrown him and his philosophy.

Yes, Haeckel belonged to the race of the giants. But how sad that he spent his life in captivity, as a mere hewer of wood and drawer of water, or milling around grinding in spiritual darkness in the house of Dagon his god, when even for him the bright sunlight of the Creator's mercy and blessing was just outside the walls of that dungeon in which he had voluntarily imprisoned himself.

History has reversed the sad fear of Keats that his own name had been written in water. Still more sad is it to have to record the verdict of history that names and theories once thought engraved in the rock forever have proved but temporary and fleeting. Saddest of all are the cases of the thousands throughout the world who might have had their names in the divine Book of Life, but who refused this opportunity because of misplaced confidence in such names and such theories as we have been considering above.

XIV

WERNER AND HIS INDEX MINERALS

COMPARED with physics and biology, or even with chemistry, geology is a young science. Its originator as a special branch of scientific study was Abraham Gottlob Werner (1749–1817), professor of mineralogy at the mining academy of Freiberg. He attracted so many students from abroad that his influence became very widely spread, among his pupils being Von Humboldt, Von Buch, and Robert Jameson, professor of geology for fifty years in Edinburgh University, with many others.

Werner's ancestors for three hundred years had been connected with the mining industry, and he himself knew about all there was known at that time about rocks and minerals, though his theories about their formation were antiquated even for his own day. He had three years at Leipzig University, studying law and modern languages; but he returned to his first love, and by the age of 26 he found himself at the head of the recently founded mining school, which by his genius as a teacher he raised in forty years to a position almost like that of a university. He had a most delightful way of making his lectures on minerals a mental springboard for going off into all the various topics of history or economic life which could possibly be connected up with his favourite theme. The result was that students came to him from all the civilized world, returning home as flaming evangelists of the new learning, which in that day was called " geognosy," the term " geology " coming in later. It is said that men in foreign countries even in middle life studied German in order to attend the lectures of the great prophet of geognosy.

The patriarch Job wished that his words were written in a book, that such a document might be an eternal witness of what he had said. Unfortunately we do not have any such testimony regarding Werner's theories; he did not put them in permanent form, though he has left a pamphlet or two consisting of little more than a list of the various rocks and minerals. Accordingly we have to depend upon the notes and reports of his pupils. His theories may not have appeared originally as absurd as they now seem to us; but we have to take them as they have been passed along to us second-hand. This keen-eyed German, with his dimpled cheeks and extreme trimness of person, was certainly no fool, though the bald statement of his cosmological theories may sound very foolish to us. Another thing should be remembered here. We are dealing only with Werner's theories about *origins;* and these theories of origins may have occupied only a very small part of his attention, his teachings may have been almost wholly concerned with common-sense descriptions and occurrences, etc., of his rocks and minerals. For it is very often the case with teachers that—

> *"The evil that men do lives after them;*
> *The good is oft interred with their bones."*

With this caveat to the reader, we must proceed to study the theories of this interesting man. For, to quote the words of Sir Archibald Geikie, "No teacher of geological science either before or since has approached Werner in the extent of his personal influence or in the breadth of his contemporary fame" (*The Founders of Geology*, p. 209; 1905). The other historians of geology, Whewell and Zittel, agree in this estimate.

Others before him had taught the universal spread around the earth of the mineral "formations," or suites of rocks. Werner adopted this idea ready-made, doubtless without any critical examination of its logic or its reasonableness; and under his extreme love of order and systematic classification this idea became very precise. He seems to have had an ambition to do for mineralogy what Linnæus had done for botany; unfortunately, he brought in the element of *time* into his classification, which Linnæus never did with his plants; and it was on this time-value of his minerals that his whole theory went to shipwreck.

All the rocks and minerals had, as he declared, once been held in solution by the universal ocean, and had been precipitated one after another, the sequence in which he happened to find them in his native Saxony being (as he assumed) the infallible guide for their order of occurrence in all the rest of the world. He was absolutely certain of the exact order in which all the various kinds of rocks had been formed from this universal ocean, because of the order in which he found them now occurring; for he treated his various minerals as "*index minerals*," each giving the age of the rock in which it was found relative to other rocks elsewhere. In other words, each mineral with him became the infallible label or ticket showing the age of the rock deposit where it was found. And he taught this precise sequence with as much confidence and sheer dogmatism as if he had been present with a camera (pardon the anachronism) and had actually taken moving-pictures of the entire process from the beginning.

As we shall see in the next chapter, this idea of a time-value was ultimately given up regarding the minerals, but was transferred from the minerals to the *fossils;* so that instead of index minerals we now have "*index fossils*," and these are to-day regarded with the same superstitious faith in their time-value as Werner bestowed upon his minerals.

The two cases are precisely parallel, and the modern idea is just as intrinsically absurd as was the former one, and is in the light of modern discoveries just as positively contradicted by the facts of nature. With all this in mind, we must now proceed to study the relative ages of the rocks according to Werner's classification, which is usually termed the *onion-coat* theory, as he believed these various successive sheets of rock occurred all around the globe one outside another like the successive coats of an onion.

I. According to his scheme, the first rocks to be precipitated were of purely chemical origin, and he called them *Primitive;* they included granite, the oldest, then gneiss, mica-slate, clay-slate, serpentine, basalt, porphyry, finishing with syenite as the youngest of this group.

II. Next came what he termed the *Transition* rocks, chiefly of chemical origin, but comprising also some that had been mechanically deposited, as greywacke, greywacke-slate, and limestone, their deposition indicating that the universal ocean was gradually lowering in level.

III. The mountains had by this time been raised above the ocean, so that the rest of the formations were not exactly universal around the globe, though their relative ages were just as definite as before. The third group were the *Floetz* rocks, including sandstone, limestone, gypsum, rock-salt, coal, basalt, obsidian, porphyry, with various others. These *Floetz* rocks were regarded as having been formed chiefly as mechanical sediments, though Werner was just as certain of the precise sequence in which they occur all around the globe.

IV. Latest of all came the *Alluvial* series, consisting of recent loams, clays, sands, gravels, sinters, and peat (Geikie, *Founders of Geology*, pp. 214, 215).

All the historians of geology agree that this precise order of the various rocks was announced as a solid body of well ascertained truth, about which there could be no further doubt or dispute.

Werner seems never to have faced the problem of what had become of his great universal ocean, or how it had subsided to its present dimensions. His ardent pupil, Robert Jameson, who was professor of geology in Edinburgh University, dying in 1854, tried to face the problem as follows:

"Although we cannot give any very satisfactory answer to this question, it is evident that the theory of the diminution of the water remains equally probable. We may be convinced of its truth, and are so, although we may not be able to explain it. To know from observation that a great phenomenon took place, is a very different thing from ascertaining how it happened" (R. Jameson, *Geognosy*, p. 82).

It seems to me that we have heard this sort of reasoning in quite modern times, to the effect that we may be firmly convinced of the general "fact" of organic evolution, even though we cannot see any possible method of nature by which it could have taken place. Such is the language of a theory in its dotage; its supporters are fighting with their backs to the wall, most of the known facts having already turned traitors and being now arrayed in conspiracy against the theory.

Werner had adopted the leading ideas of his scheme when he was just beginning his teaching, and when his field experience was extremely limited. But having once adopted them he maintained them until the end. He himself never travelled outside of the narrow little district of Germany where he had been born and brought up. His pupils, however, like Humboldt and Von Buch, travelled a good deal, and wherever they went they thought they found the rocks in the same relative sequence which Werner had taught them to expect. But not always; for gradually examples were reported to the Saxon professor which seemed to contradict his scheme. Some granites, for instance, were found lying on top of the slates of the Primitive series, instead of underneath them; some greenstones, which Werner had placed among the Primitive rocks, were actually found interbedded with rocks of the Floetz series; porphyry was also found occurring in several of the "later" groups, though it had been assigned to the Primitive.

These facts were admittedly troublesome; but they were met by prefixing such modifying terms as "oldest" or "newest" to the various reappearances of the same kind of rock, or by giving them numbers according to their positions in the series. "Thus there were oldest and newest granites, oldest and newer serpentine, and first, second, and third porphyry formations" (*Founders of Geology*, p. 232).

In this way the general scheme was patched up and saved, though obviously at the cost of logic and clear thinking. As Geikie very well expresses the matter:

"The modifications rendered necessary by fresh discovery proved that the supposed definite sequence did not exist. In fact, as was well said by a critic at the time, they were mere 'subterfuges by which the force of facts was evaded.' They were devised for the purpose of bolstering up a system which was entirely artificial, and to the erroneousness of which new facts were continually bearing witness" (p. 232).

We must remember this expression about mere "subterfuges" by which the force of facts is sought to be evaded, and see if there are any such devices in the modern system of geology, when we come to deal with such theories as "thrust faults" and "deceptive conformities." Perhaps we shall find that it is still true, as Herbert Spencer stated a half-century ago, that "though the onion-coat hypothesis is dead, its spirit is still traceable under a transcendental form even in the conclusions of its antagonists."

The war between the "Neptunists," as Werner and his followers were called, and the "Plutonists" or "Vulcanists," as his opponents, the followers of James Hutton (1726–1797) were called, came to an issue over the origin of basalt. Its striking resemblance to modern-formed lava, which can be seen actually issuing from modern volcanoes, was a hard problem for Werner to solve; but he showed his ingenuity and resourcefulness by saying that if the basalt is found occurring on an isolated hilltop, it is to be regarded as a member of the Floetz-trap formation, having been precipitated by the universal ocean; but if found obviously associated with modern lava, we must say that the original precipitate has since been fused by volcanic action. Evidently it is going to be difficult to corner a man with such a "heads-I-win-tails-you-lose" argument. And yet the modern men, who can invent a "thrust fault" whenever they find their "index fossils" in the wrong sequence, are just as invincible.

I cannot help wondering whether Geikie may not have had some misgivings about the logical soundness of his own system of "index fossils" when he penned the following scathing indictment of Werner's unscientific methods:

"Never in the history of science did a stranger hallucination arise than that of Werner and his school, when they supposed themselves to discard theory and build on a foundation of accurately-ascertained fact. Never was a system devised in which theory was more rampant; theory, too, unsupported by observation, and, as we now know, utterly erroneous. From beginning to end of Werner's method and its applications, assumptions were made for which there was no ground, and these assumptions were treated as demonstrable facts. The very point to be proved was taken for granted, and the geognosts, who boasted of their avoidance of speculation, were in reality among the most hopelessly speculative of all the generations that had tried to solve the problems of the theory of the earth" (p. 212).

And yet one could substitute such names as Lyell, or Geikie, or Dana, or Schuchert in the above passages, and the statements would still read just as true and accurate for the prevailing system of evolutionary geology to-day as they are when applied to Werner of a hundred years ago. The modern scheme of "index fossils" is just as intrinsically absurd, just as contrary to all scientific methods, and just as contrary to proved discoveries in the field, as was the system of "index minerals" here so severely but so justly denounced. Werner's system lasted fifty years or so; the modern system has had a vogue of a hundred years; which indicates that it has taken twice as long to detect the false logic of "index fossils" as it did to discover the blunder about "index minerals." But the two systems are precisely parallel in every respect; and there is no more real science about the one than about the other.

Of course, after the repeated discovery of rocks in a sequence directly the reverse of the "standard" order formulated by Werner, when the old system could no longer support itself in spite of repeated patching and tinkering, the onion-coat theory with its "index minerals" had to be abandoned.

Unfortunately, as already intimated, a fresh scheme of onion coats, this time based upon the fossils of ancient plants and animals, was substituted for the former one, giving the system of long successive ages a new lease of life, and laying the foundation for the modern theory of organic evolution.

This biological onion-coat theory, with its precious "index fossils," will be considered in the next chapter.

XV

"STRATA" SMITH AND HIS INDEX FOSSILS

WILLIAM SMITH (1769–1839), nicknamed "Strata" Smith by his contemporaries, was the son of a poor farmer in the west of England who died when the boy was eight years old. The youth was brought up by an uncle, but he never had more than the crude elementary schools of those days gave in the way of an education. He was early apprenticed to a land surveyor, and managed to pick up by himself a familiarity with the tools and the slight amount of mathematics necessary for that business as then conducted. At the age of twenty-four we find him engaged as assistant in laying out a coal canal, with which enterprise he was connected for six years. At the age of thirty he was out of a job, and started out as a surveyor on his own account. This work took him around through all the middle and southern parts of England; but he never set foot outside of the Island of Great Britain.

Early in his career he discovered a method of following the rocks of one locality over to a distant outcrop, his method being to identify a rock by means of the curious objects contained in the beds, which the ignorant peasants (to which class Smith belonged) used to call "pundibs" or "quoit-stones," and which we now identify as fossil brachiopods and echinoids. He did not know the scientific significance of these objects, nor even their names; but his method of tracing the underground layers of rock by their means worked well, and he gained confidence in its use. It was a purely bread-and-butter interest which he had in thus identifying the various strata; for it gave him a key to the valuation of land, and his knowledge of the country was of much value in his business in laying out water works, digging wells, and in various ways.

He was capitalizing his knowledge of the rocks by making a good living. But he saw that other people with education were becoming interested in his findings; so he began to embody his ideas in maps, by which he endeavoured to portray the underground conditions in this part of England. More and more this map-making became a hobby with him, so that he came to spend all his spare time and money in this manner. Ultimately he lost all the little property he had accumulated, because a stone quarry on his land near Bath gave out—evidently his knowledge of even the rocks here near his own home was not perfect. He found himself heavily in debt; he had to sell all his precious collections of fossils, which were in the emergency purchased by the British Museum. Ultimately he was granted a pension of a hundred pounds a year by the Government, under the advice of some members of the Geological Society.

Both Smith and Werner are good examples of the fact stated by Dr. W. W. Watts in a recent paper, where he says that the leading methods of geology "were evolved in the early days of physics and chemistry and by men often ignorant even of such principles as were then understood" (*Annual Report of the Smithsonian Institution*, 1925; p. 282). But while Werner did have some educational advantages, Smith had essentially none at all.

Geikie gives the following statement of Smith and his work:

"His plain, solid, matter-of-fact intellect never branched into theory or speculation, but occupied itself wholly in the observation of facts. His range of geological vision was as limited as his general acquirements. He had reached early in life the conclusions on which his fame rests, and he never advanced beyond them" (p. 395).

It certainly would be to Smith's credit that he never went off into theory or speculation, if this were really true. About this we shall judge presently. But Geikie is undoubtedly correct in saying that Smith's "geological vision was as limited as his general acquirements"; and we must not forget that his "general acquirements" were essentially *nil*.

Smith did not publish any books, though he left voluminous and ill-arranged notes which became the despair of those who tried to do something with them. His main idea, the one thought running with monotony through them all, was that throughout all the middle part of England the same strata are always found in the same relative order of superposition and containing the same kinds of fossils. Accordingly, distant outcrops of any of these strata can be identified by their contained fossils, even when these outcrops are distant many miles from one another.

So far so good. But Smith went much farther than this when he pictured all these strata in England as dipping in an eastward direction, and then extended this easterly dip *to all the strata all over the globe*. Nobody ever accused him of reading much scientific literature, least of all general literature; but he surely must have got hold of Werner's onion-coat theory somehow. For when Smith tries to deal with the world as a whole, one would almost suspect him of having taken over bodily the notes from some orthodox disciple of Werner.

In a manuscript dated December 2, 1786, and evidently intended for publication, we find Smith describing how outcrops on opposite sides of a valley or a channel often prove to belong to the same continuous beds; and he argues that we may extend this same rule so as to *apply it to strata on* *opposite sides of an ocean, and thus all around the globe.* Thus he says:

"The strata being found as regular on one side of a rivulet, river, deep valley, or channel as on the other, over an extent of many miles, when proper allowance is made for the inclination and for the variation of the surface, is it not reasonable to suppose that the same strata may be found as regular on one side of the sea or ocean as on opposite sides of a deep valley upon land; and if so, and the continuation of the strata is general, what is their general direction or drift? Is it in straight lines from pole to pole, or in curved lines surrounding the globe regularly inclined to the east?" (*The Heroes of Science*, p. 250; by Prof. P. Martin Duncan, Vice President of the Geological Society; 1882).

With tiresome monotony Smith reverts over and over again to this idea that all the strata of England keep dipping constantly to the east or the southeast; and he so dinned this idea into the heads of the professional geologists that they all expected to find thick Carboniferous beds deep beneath the Chalk in the south of England; but subsequent boreholes have proved that, while there are some coal beds here beneath the Chalk, they have no physical connection with either the coal seams in the west of England or those in the north of France. (See *Nature*, April 20, 1929.) Even if a physical identity were proved in these instances, what an awful hiatus in logic it would reveal to extend this relative sequence of the strata in this small locality to all the rest of the world,—"*in curved lines surrounding the globe regularly inclined to the east.*" Werner's onion coats in all their glory were not arrayed in language any more childish than is shown by this language of William Smith, who is constantly called "the Father of English Geology."

We must remember that both Smith and Werner were untravelled men; both took the rocks as they found them in small localities and assumed that the sequences with which they were familiar would always be found prevailing all over the globe. Lyell tells us that within a few hours' walk of Werner's home rocks have been found directly contradicting Werner's theory. Similarly within the area walked over by Smith so many times contradictions to his theories have since been discovered. But the mistakes in logic made by both men are far more serious, and they are the same kind of blunder in both cases. As Whewell says of Werner, "He promulgated, as respecting the world, a scheme collected from a province, and even too hastily gathered from that narrow field" (*History of the Inductive Sciences*, Vol. II, p. 521). And every subsequent writer dealing with Werner's theory has said what is equivalent to the same thing. Why is it that modern writers, who are supposed to have some training in elementary logic, cannot see that Smith's scheme (which still prevails) is just as logically unsound and unscientific for the world as a whole?

When the geologists of the early nineteenth century found that Werner's index minerals would not work in other countries, they turned to Smith's index fossils, and tried again. And they have kept on trying this new scheme from that day to this. As it has happened, the fossils have proved much more accommodating than the minerals; so the world has taken longer to wake up to the logical blunder involved. But the large areas already discovered in the Alps, in the Salt Range of India, in the Southern Appalachians, in the Rockies of Alberta and Montana, in fact all over the globe wherever detailed study of the rocks has been carried out, are gradually proving that neither Werner nor Smith was ever gifted with any supernatural insight into the sequence in which the rocks would be found occurring on the other side of the globe. And in the minds of all unbiased reasoners, the modern theories of " thrust faults " and " deceptive conformities " are just as truly mere " subterfuges " by which the force of facts is sought to be evaded, as ever were the makeshifts of Werner to keep his scheme intact in spite of the discoveries of rocks in situations contradicting his theories.

I am well aware that the illustrious Baron Cuvier (1769–1832), the most accomplished scientist of his day, the founder of several distinct lines of natural science, was contemporary with Smith and (quite independently) was working out the sequence of the fossil-bearing strata around Paris; and that Cuvier's work perhaps had more real influence on the world in switching geologists off from Werner's index minerals to the theory of index fossils. But the logic is the same in either case: Cuvier had no more knowledge of how the rocks would be found occurring around on the other side of the world than Smith had. And Cuvier no more than Smith was back at the beginning of the world's history with a moving-picture camera to take authoritative records of the exact order in which the rocks were laid down. I have already devoted two volumes largely to a discussion of these matters, and cannot expand on the subject here. (See: *The New Geology, A Textbook for Colleges,* 1923; also *Evolutionary Geology and the New Catastrophism,* 1926; both by the present author.)

As I have remarked elsewhere, probably ninety-nine per cent. of the blunders of science have been due to blunders in logic, rather than to mistakes in field observations or to mistakes in the laboratory. The mistake of the modern onion-coat theory with its index fossils is a series of mistakes in logic; only it has taken the world much longer to see these mistakes than to see the blunder of A. G. Werner; because of the fact that there were only a few dozen different kinds of minerals and rocks for Werner to deal with, while there are thousands and thousands of index fossils, and the arrangement of the sequence of the latter is a far more adjustable and a far more elastic affair than the arrangement of the former. Hence it has taken over a hundred years to detect the absurdity of the index fossils, whereas it needed only about one generation to see the absurdity of the index minerals. But the two cases are exactly parallel; and there is no more logic or real science in the one case than in the other.

The mills of the logic of science grind slowly, but they grind exceeding small.

XVI

LYELLISM

THE man who made the new science of geology a going concern was Sir Charles Lyell (1797–1875). Like Darwin he was born in a family of means; but unlike Darwin he was a good student at school and at college. He had planned to become a lawyer, and after graduation even practiced for a while; but severe eye-trouble seemed to forbid this as a career. So he turned to geology, in which he was already much interested. William Smith's new views especially attracted him. Werner's theories were becoming unpopular, and young Lyell quite disagreed with the prevailing theories of successive catastrophes, having at the early age of twenty made some shrewd observations on his own account on the coast of England which set him in revolt against the generally accepted views.

Unlike Werner and Smith, and even unlike Darwin except for his one long voyage, Lyell was a great traveller. He told his friends, "We must preach up travelling as the first, second, and third requisites of a modern geologist." A large part of his long life was spent in leisurely trips all over the western part of Europe, as well as the eastern part of the United States. He became personally acquainted with all the prominent geologists and biologists of his time, and kept fully abreast with all that was then known about the world and the animals and plants upon it. Though handicapped by weak eyesight, he steadily persevered at his chosen work, and became a graceful and forceful writer, labouring constantly at his text-books of geology, revising them from one edition to another, until he became the most famous geologist in the world, and next to Darwin the best known scientist in the entire world. He was buried in the Abbey, a burial which England reserves for those whom she considers worthy of all honour.

If now we examine the specific theories of Lyell, we are impressed with the man's hard-headed common sense. He was always looking for facts, for evidence; even late in life he showed over and over again that he could be convinced by newly discovered facts. Unlike Darwin he was a born critic; though it is a pity that he took over without sufficient examination and criticism the theories of index fossils already prevailing in his day.

The theory for which he became famous, the theory of uniformity, was not intrinsically unreasonable, especially when considered as a mere revolt against the many successive world-catastrophes which were the orthodoxy of his time. For it is quite the proper thing, the proper scientific method, to assume the normal order of nature as having prevailed in the past *until we find absolute evidence to the contrary.* And so long as he and the rest of the world believed that the fossils show a regular graded sequence from the lowest and smallest forms of life up to the highest, it was perfectly proper for Lyell to protest against the wild theories of many successive catastrophes and try to explain the past in terms of the present.

But in our day there are two lines of argument against Lyellism. The first is against the old view that the coasts of the continents are at present on the see-saw up and down. Edward Suess, in his monumental *Face of the Earth* (Oxford Ed., 4 vols.; 1904–1908), showed that the evidence supposed to point in this direction has been misunderstood; and Prof. Douglas Johnson, of Columbia University, by his work on the shoreline of the United States, puts the quietus on this entire line of Lyell's argument. Says Johnson:

"At present all arguments for changes in the relative level of land and sea based on observed changes of mean sea level are open to suspicion" (*Science,* January 7, 1927).

The second line of argument against Lyell's uniformity is based on the modern study of deep-sea conditions. Lyell and his followers assumed that the ocean currents are all the time doing real geological work at the bottom of the oceans; but we now know that this is not the case. The ocean currents are very superficial in their action, and at the bottom of the deep seas there reigns a perpetual calm; so that no true stratified formations are now forming there at all. Yet all of our stratified rocks on the continents contain deep-sea fossils interbedded with other fossils from the lands—conditions which are wholly without explanation in the light of present day conditions.

In addition to these arguments against Lyell's specific doctrine of uniformity, we also know now that it is a gross mistake to try to arrange the fossils in any such graded series as he depended upon, which he took over uncritically from William Smith and Cuvier. This arrangement of the fossils in a graded series for the world as a whole is a purely artificial scheme, *good as a mere scheme for classification purposes, but without the slightest scientific value as a definite chronology for the world as a whole.* We have seen that the system of index fossils is no more scientific than the system of index minerals. And with this criticism of the time-value of index fossils, comes the collapse of the entire chronological system as depended upon by Lyell and his followers for the world as a whole.

If now we face the problem that the trilobites cannot be proved to be older than the dinosaurs or than the great extinct mammals, and begin to ask, How were the fossils buried? we find that we have a very different problem before us than Lyell ever faced. In this form the question is no longer capable of being answered as he answered it. How utterly absurd it would be to try to explain the destruction and burial of the coal beds, the ammonites, the corals, the crinoids, the dinosaurs, the elephants, in any slow gradual manner after the present order of the elements, if all these kinds of life actually *lived together contemporaneously in the same world.* No one would dream of trying a scheme of uniformity under these conditions. One huge world-catastrophe would be the only possible solution of the problem.

But Lyell did not have a tithe of this evidence. He had implicit confidence in the value of "index fossils," as taught him by Smith and Cuvier. In Lyell's day no breath of suspicion had ever been breathed against the time-values of the fossils, so far as I have been able to learn from a study of the history of the science. And with the value of the "index fossils" still believed in, and with his ignorance of deep-sea conditions and his belief in the reported ups and downs of the coast, Lyell's theory was quite reasonable.

Also, with Lyellism fully established and regarded as proved science, we can say that Darwin was not unreasonable in trying to find some naturalistic explanation of the change from one kind of fossil life into the one thought to be its successor in time. For Lyell's uniformitarian geology seemed to make some scheme of organic evolution absolutely necessary. And the current system of uniformitarian geology makes some sort of organic evolution necessary *for all who still believe in it.* Uniformitarian geology seems to offer independent proof for evolution; in reality the major part of the evolution scheme is already in the geological part; the rest is a logical necessity, if the first is accepted. It is quite unreasonable to hold to the first and refuse the second. Accordingly, it is fatally inconsistent for Fundamentalists and other opponents of evolution still to admit Lyell's scheme of geology, based as it is on artificial series of "index fossils" as the infallible tickets of the exact age of any newly discovered rock deposit. They cannot oppose a belief in organic evolution, if they accept Lyell's geology.

In our day, with all the abundant proofs which we now have, there is not the slightest excuse for any intelligent person's saying that the Cambrian fossils, wherever found around the world, are always older than the Carboniferous, or the latter older than the Cretaceous or than the Tertiary. But if we cannot with the sternest and clearest logic maintain these relative ages of these "index fossils," what is the possible sense of trying to construct some system of organic evolution? The stories of *Alice in Wonderland*, the *Wizard of Oz*, or any other form of "Jabberwocky" would be about as scientific.

For the modern man of science who is determined to hold only to rigorously established facts, the issue is very plain. He may adopt an agnostic attitude and say that we do not know how the fossils were buried. He may persist in affirming (in spite of the evidence) that a great world-catastrophe is quite inconceivable, that it would be a real miracle, and that science can never acknowledge miracles. But if so, it will be quite useless for him to assume a miracle of supernatural knowledge on his own account, and claim to know the intrinsic values of the various "index fossils," when we are all aware that there is no scientific method of proving the time-values in which he is trusting. He is building his scheme of evolution on a myth; for geology is fooling him when it asserts a time-value for its "index fossils." The latter simply represent the newer form of the old discarded onion-coat theory; and in the light of modern knowledge, the theory of "index fossils" is just as unreasonable and as unscientific as the former theory of "index minerals."

XVII

THE LIMITATIONS OF KNOWLEDGE

THERE may be some investigators of natural phenomena who affirm that they have no interest in the problem of the limitations of knowledge. If so, they may very easily omit this chapter. There may be some specialists, engaged in breeding fruit flies, or guinea pigs, or studying the fuselage of an airplane, or the best construction of a broadcasting station, or some new feature of the benzene ring, who are at the present time not particularly concerned with such a problem. A person may be too busy with the individual tree in front of his own nose to take any interest in the landscape. But sooner or later even such a person will need to understand how much we have a right to expect from scientific investigations.

Men of science are fast becoming more specialized than other investigators. This means that scientific men are becoming more and more dependent upon one another for that general picture which they present to the public as the scientific view of the world. Also they are becoming more and more dependent upon what others have discovered for their own personal view of the world. Instead of being men of knowledge, they are fast becoming men of faith,—of faith in what the other fellows have actually proved. No human mind can to-day compass more than a moiety of the details of what has been discovered in nature; any man who could imagine he had accomplished such a feat would be too completely a fool to start with ever to realize that he had failed. And the actual amount of facts which any one of us can possibly know first-hand is still smaller. For all the rest of our scientific knowledge, outside of the few facts which we may claim to know of ourselves or at first-hand, we are always dependent upon the *bona fides* plus the good sense and the sound logic of hundreds of others for what they claim to have discovered.

The geologist takes things on faith from the astronomer; he takes things on faith from the chemist, unless he happens to have had a very thorough course in chemistry himself. He takes many things by faith from the physicist; and he takes oh, so many, many things from the zoölogist and the botanist, and even still more important " facts " from the specialist in some phase of palæontology, who may affirm that such and such fossils are " extinct " species. For the entire momentous problem of the exact " age " of a newly discovered set of beds may turn upon whether the fossils found in these beds are specifically identical with certain ones living to-day or must be classed as another " extinct " species. And when it comes to the ordinary scientist, who may have specialized in chemistry, or physics, or protozoölogy, or pathology, or radioactivity, or a hundred other lines of modern science, how completely is he dependent upon the *bona fides* and the sound logic of the geologist and the palæontologist and the biologist for everything that he is to believe regarding such a generalization of all generalizations as is represented by the theory of man's ascent from the lower animals. Evidently there are some men of science who have never heard of the rule for legal evidence (which is just as applicable to scientific evidence) that we must never base an inference on an inference. Certain is it that the amount of faith in others which is represented by any man's acceptance of the theory of organic evolution is really colossal.

Accordingly, well trained scientists as well as other people need to understand very clearly the real limitations of human knowledge. Of course, persons with little or no scientific training, men who may be highly educated in literature, or languages, or history, or music, yet who may have no first-hand acquaintance with any particular line of science, should be especially careful to understand these limitations. For in our day the actual discoveries and accomplishments of the students of nature have so astonished and dazzled the eyes of the rest of the world, that there is a constant danger that all the rest of mankind will take the unverified assertions of those who claim to be men of scientific training. Often in the past has the world been imposed upon by pretenders to knowledge; there was never more danger of being thus imposed upon than to-day.

Hume was skeptical regarding the pretenders to metaphysical knowledge. He devoted his life to showing how little we can claim to know about the inner nature of qualities and causes. Yet, in spite of the lessons of the past, the workers in the various natural sciences have combined (I must not say conspired) to build up an enormous structure, of which the cupola is labelled "Evolution." But every one knows that very many metaphysical uncertainties have been built into the very foundations of this structure. Is it not time for some one to shout "Out from under!" ere many confiding souls are buried in the imminent collapse of the hastily constructed edifice?

Let us for instance take a brief glance at a part of this structure which has already collapsed, I mean its prophecy of the future. For the age of Darwin was very sure about the bright future before the world; the portals to the millennium were wide open, and they were just about to cross the threshold. As Langdon-Davies expresses it, "No religious sect ever announced the millennium so openly as did the scientists of Spencer's generation."

Take these representative statements from Herbert Spencer:

"Progress is not an accident but a necessity. What we call evil and immorality must disappear. It is certain that man must become perfect."

And again:

"The ultimate development of the ideal man is certain—as certain as any conclusion in which we place the utmost faith; for instance, that all men will die."

Darwin himself taught essentially the same thing. In the very close of his *Origin of Species* he argues that since no cataclysm had ever desolated the whole world, "we may look with some confidence to a secure future of great length. And as natural selection works solely by and for the good of each being, all corporeal and mental endowments will tend to progress toward perfection."

Where were Spencer and Darwin and their innumerable followers getting this boundless optimism? They thought they were getting it from the very logic of their theory of evolution.

How does that optimism agree with the modern view of the future, as given by such men as Bertrand Russell, Prof. Schiller, or J. B. S. Haldane? The moderns are very pessimistic, saying that there is no law of progress, and that the human race is likely to destroy civilization itself.

Do not these modern pessimists consider themselves to be just as "scientific" in their pessimism as Darwin and Spencer were in their extreme optimism? Of course.

What is the reason for this radical disagreement? Certainly not in their science, but in their philosophy and their metaphysics. All such views about the world in general are almost wholly metaphysics or philosophy, diluted a little with what their advocates are pleased to term science. Apart from divine revelation, what any man really knows about the future is absolutely *nil*. The shame of it all is that such sheer speculations have been and are still bandied about as the teachings of " modern science."

Those who have made themselves acquainted with the history of scientific discovery realize that many very different types of mind have been engaged in the work of building up that imposing structure which we call modern science. Some like Kepler have by enormous labour tried hypothesis after hypothesis, until at last the absolutely fitting one has been discovered. Some like Caspar Friederich Wolff, the propounder of *epigenesis,* seemed to hit on the real truth by pure *a priori* reasoning, though most theories thus discovered have kept science wandering long in the wilderness. Some few, like Gregor Mendel, have by the strictest scientific methods ploughed their way straight through to ultimate truth, a truth which could then be verified and demonstrated by all the world. Unfortunately, many like Lyell and Darwin have taken over uncritically from their predecessors an unassorted mixture of some truths and some unverifiable assumptions, then by seeking supposed verification in the field have accumulated a vast mass of facts many of which have seemed to confirm their hypothesis, while a larger or smaller residue of facts have refused to be brought within its range. In such cases as the latter we may be sure there is a vital wrong somewhere; and the obvious presumption is that the fault lies in some of the unverifiable assumptions uncritically taken over from their predecessors.

If now I am asked what are these unverifiable assumptions which have been incorporated into the systems of Lyell and Darwin, I would name but two: firstly, the tacit or explicit denial that any great world-catastrophe could possibly have happened the world in the long ago; and secondly, the bald assumption that life has occurred on the earth in a long-drawn-out series of gradually increasing complexity and development. These two assumptions have shaped the entire modern system of evolutionary geology, and through geology have come to fruition in the modern detailed form of the theory of organic evolution; though even a child can see that the entire scheme of evolution is implied in the second of these assumptions, and is inextricably bound up with the first.

That both are assumptions pure and simple, without a shadow of support in inductive science, will be clear to any one who will read attentively my *Evolutionary Geology*. I have not the space to develop the matter here.

But if these are really unverifiable assumptions, surely the modern *impasse* regarding evolution ought to suggest to us that probably these assumptions *are wrong*. For if they are wrong, that would clear up the present muddled situation tremendously.

Much the same remarks might be made regarding the former views of physics and chemistry when dealing with such ideas as "force" and the alleged "properties" of matter. Fortunately many others have pioneered in these fields, and so the subject is not now so difficult.

Every intelligent man knows that when we speak of the *force* of gravitation, or the *force* of magnetism, we are simply giving a name to an observed behaviour of matter; the name is that of a *process*, not a *thing;* and it does not in the least "explain" the why or the how of this process. As already remarked in the preceding pages, many leading scientists of our day are now saying openly that we do not have any mechanical or materialistic explanation of these fundamental "forces" of nature; they seem to be merely manifestations of the direct fiat-action of the great Ruler of the Universe. The same appears to apply to the problem of light and all forms of radiation.

In the field of biology, we have also been able to clear up some former misunderstandings. The unit of life is the cell; many forms of life being composed of numerous cell-companies which work in coördination for a common purpose. I do not see how an instructed Christian can any longer look upon the behaviour of the cells as other than mere automata similarly under the direct fiat-control of the Master Mind of the universe. It seems to me that every discovery of modern biology is pointing in this direction.

But these considerations make it a very simple matter to say that this same Power, thus intimately connected with all the phenomena of the world, must in the past have had a continued supervising control not only of the careers and destinies of nations but of the world as a whole. And if we are assured in those writings which claim to be a direct Revelation from this Ruler of the universe that at a certain period in the past He called a halt to man's career of wickedness by deliberately overwhelming the race by the waters of a universal Deluge, thereby changing that edenic world, with its easy means of living, over into a world where man has had to struggle for his very existence, I do not see why we should consider such a world-catastrophe impossible or incredible. Certain is it that those who still believe in such miracles as the Incarnation and the literal Resurrection of the body, will show little consistency in refusing longer to believe in this record of that world-catastrophe which is not only recorded in the Bible as the most tremendous physical event which ever happened the world, but which is now so strikingly confirmed by the discoveries of modern geology and biology.

This in my estimation is the largest problem now before the scientific world.

On the one hand we have the assumption of modern evolutionary geology that such a world-catastrophe is out of the question, because quite impossible. In addition to this flat denial of such an event, we have the bald assumption that life has been on the globe for uncounted millions of years, and that it has been advancing in size and in complexity, culminating in man the crowning work of this elongated process.

On the other hand we have the divine record of a real creation of the world in a highly differentiated condition biologically, with a sudden world-catastrophe in the long ago destroying and burying vast myriads of living things which we now find as fossils in the rocks, the present world being but the partially recovered ruins of that edenic world thus nearly destroyed.

Such in the minds of thousands of well educated men and women are the two alternatives now before the world.

I and my fellow Bible-believers cheerfully admit that the latter alternative is suggested by our religion, and that it probably could never have been wholly worked out even as a hypothesis by the study of nature alone. But I do not know of any dictum of natural science study which would forbid us from trying out such a hypothesis, even though from a religious source, and seeing if it will work, that is, seeing if it gives a more reasonable explanation of the facts of nature. Certainly many anti-religious hypotheses have in the past been recognized as scientific in the fullest sense of the word; the history of the various sciences is full of them. Accordingly, I cannot see any real point in the objection that this hypothesis of a world-catastrophe has a religious pedigree. *The only question is, Will it work?*

I believe that it will work. And I believe that the next few years will see a marked increase in the number of those who agree that it offers a much more reasonable explanation of the totality of facts in geology and biology than does the evolution theory.

This is all that we ought to ask of any hypothesis which deals with so many facts and processes which are forever beyond the reach of direct verification.

But I am told that this is not the "scientific" method. What is the scientific method? Let me illustrate what the scientific method is according to some people.

I have seen two big strong men who agreed to run a race. They tied the right leg of the one up with the left leg of the other, so the two legs must move together. In this fashion they ran across the field together, amid the laughs and the hand-clapping of the crowd. They were voluntarily restricting themselves in certain particulars, and then running their race according to the prescribed artificial rules that they had agreed upon.

In the minds of many this illustrates the "scientific method." Scientists, according to them, are definitely restricted in their search for truth; they must work only within certain defined limits; they must not receive any suggestions or any help at all from outside these limits. Religion must never be mentioned in any line of scientific investigation, neither must ethics or morals, in so far as exercising any control or guidance is concerned. For instance, the moral atrocities of the Darwinian doctrine of "natural selection" must not be used as in any sense a warning that there must be something wrong with the doctrine; for they tell us that morals and ethics have nothing to do with the cold impersonal search for scientific truth. And so they stumble along, until finally they find themselves in the slough of scientific Despond, and wonder what the matter is. When if they were not working under artificial conditions of restricted action they would have known long ago what was the matter.

All of which is an attempt to illustrate the fact which ought to be better known than it is, namely, that there is no specially sacrosanct "scientific" method of reasoning which is so radically different from all other methods. Any method of search for truth in any line or on any subject is legitimate if it adheres to the well recognized rules of reasoning. But different subjects require different methods of study. The objective study of the world of nature is proper for this kind of research; it has its own methods of reasoning which are definitely known. These are legitimate enough, if we recognize that this sort of study and reasoning is dealing with only a part of reality, and if in addition we do not try to extend this method beyond its legitimate sphere.

For it is important to remember that, if the methods of science are exclusive, so is the field within which they apply. If scientists may rightfully warn off trespassers from their domain, so may students of religion warn scientists from trespassing on the ground of religion and philosophy. The trouble usually is that certain men who claim to be the especial guardians of science are inclined to claim that their methods are the only legitimate methods of human thinking about anything and everything in the universe; and then they want to take up such problems as the origin of mankind and the future of the world, matters which are far outside their own field, and discuss these matters according to those methods which they have grown accustomed to employ in dealing with the objective facts of nature.

But Christians believe that the God of the universe has given to mankind a special Revelation to tell them some things about the universe which men could never find out for themselves by the scientific method or by any other method. On looking into this Book which claims to be God's special Revelation to mankind, we learn immediately why we could never discover some of these things by our scientific method. For we read there that God actually created the world and the animals and plants in it by a process which is *not now going on;* hence we can never by reasoning from the present order of things get any true knowledge of their origin. This is one of the primary or fundamental truths of the Christian religion. Hence, if this doctrine of creation be true, no inductive or objective study of anything can possibly teach us the method of its origin—except as the objective or "scientific" method fails miserably, and thus by its failure advises us that the origin of things was by some process different from those processes which prevail to-day. In the light of these truths, common sense ought to warn any man who has any respect for the Bible from attempting to apply the so-called "scientific" method to such problems as the real origin of any objective reality in the universe.

I suppose those who do not respect or believe the Bible will have to be allowed to keep on trying to solve their little puzzle, just as some will always be found to keep on fooling with spontaneous generation, perpetual motion, the origin of the solar system, transformism, and a lot of other problems which in effect are an effort to extend the field of science and its methods over the entire universe.

But for some of us, and the number is constantly increasing, the very failure of every such attempt is a warning that these problems are outside the jurisdiction of real science, and can be understood only in the light of Revelation. These continuous and conspicuous failures to solve all the problems of the universe by the so-called "scientific" method, become a gentle reminder that perhaps the Bible may be right after all, when it declares that "In the beginning God created."

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