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THE SCIENTIFIC WORLD-PICTURE OF TO-DAY[1]

By General the Right Honorable J. C. SMUTS

AFTER what I said at the opening this afternoon it is unnecessary for me to emphasize further the significance of this Centenary Meeting of our association. It is a milestone which enables us to look back upon a hundred years of scientific progress, such as has no parallel in history. It brings us to a point in the advance from which we can confidently look forward to fundamental solutions and discoveries in the near future, which may transform the entire field of science. In this second and greater renaissance of the human spirit this association and its members have borne a foremost part, to which it would be impossible for me to do justice to-night. I shall therefore not attempt to review the achievements of this century of science, but shall content myself with the simpler undertaking of giving a generalized composite impression of the present situation in science. The honor of presiding over this historic meeting, which was not of my seeking, and for which I was chosen on grounds other than my personal merits, is indeed an almost overwhelming one, and I confidently appeal for your indulgence in the difficult task which awaits me to-night.

I am going to ask the question to-night: What sort of world-picture is science leading to? Is science tending towards a definite scientific outlook on the universe, and how does it differ from the traditional outlook of common sense?

The question is not without its interest. For our world-view is closely connected with our sense of ultimate values, our reading of the riddle of the universe, and of the meaning of life and of human destiny. Our scientific world-picture will draw its material from all the sciences. Among these, physical science will—in view of its revolutionary discoveries in recent years—be a most important source. But no less important will be the contribution of the biological sciences with their clear revelation of organic structure and function as well as of organic evolution. And last, not least, the social and mental sciences will not only supply valuable material, but especially methods of interpretation, insights into meanings and values, with-

[1] Address of the president of the British Association for the Advancement of Science, London, September 23, 1931.

out which the perspectives of our world-picture would be hopelessly wrong.

Can we from some reunion or symposium of these sciences obtain a world-picture or synoptic view of the universe, based on observation and calculation, which are the instruments of science, but reaching beyond the particular phenomena which are its immediate field to a conception of the universe as a whole?

That was how science began—in the attempt to find some simple substances or elements to which the complex world of phenomena could in the last analysis be reduced. The century over which we now look back, with its wonderful advance in the methods and technique of exact observation, has been a period of specialization or decentralization. Have we now reached a point where science can again become universal in its ultimate outlook? Has a scientific world-picture become possible?

Of course there can be no final picture at any one stage of culture. The canvas is as large as the universe, and the moving finger of humanity itself will fill it in from age to age. All the advances of knowledge, all the new insights gained from those advances will from time to time be blended into that picture. To the deeper insight of every era of our human advance there has been some such world-picture, however vague and faulty. It has been continually changing with the changing knowledge and beliefs of man. Thus, there was the world of magic and animism, which was followed by that of the early nature gods. There was the geocentric world which still survives in the world of common sense. There is the machine or mechanistic world-view dominant since the time of Galileo and Newton, and now, since the coming of Einstein, being replaced by the mathematician's conception of the universe as a symbolic structure of which no mechanical model is possible. All these world-views have in turn obtained currency according as some well-defined aspect of our advancing knowledge has from time to time been dominant. My object to-night is to focus attention on the sort of world-picture which results from the advances of physical, biological and mental science during the period covered roughly by the activities of our association.

Science arose from our ordinary experience and common-sense outlook. The world of common sense is a world of matter, of material stuff, of real separate things and their properties which act on each other and cause changes in each other. To the various things observable by the senses were added the imperceptible things—space and time, invisible forces, life and the soul. Even these were not enough, and the supernatural was added to the natural world. The original inventory was continually being enlarged, and thus a complex empirical world-view arose, full of latent contradictions, but with a solid basis of actual experience and facts behind it.

Speaking generally, we may say that this is substantially still the common-sense view of the world and the background of our common practical beliefs. How has science dealt with this common-sense empirical world-view? The fundamental procedure of science has been to rely on sense observation and experiment, and to base theory on fact. Thus the vast body of exact science arose, and all entities were discarded which were either inconsistent with observed facts or unnecessary for their strict interpretation. The atomic view of matter was established. Ether was given a status in the physical order, which is now again being questioned in the light of the conception of space-time. New entities like energy emerged; old entities like forces disappeared; the principle of the uniformity of nature was established; the laws of motion, of conservation and of electromagnetism were formulated; and on their basis a closed mechanistic order of nature was constructed, forming a rigid deterministic scheme. Into this scheme it has been difficult, if not impossible, to fit entities like life and mind; and the scientific attitude has on the whole been to put them to a suspense account and to await developments. As to the supernatural, science is or has been agnostic, if not frankly sceptical. Such, in very general terms, was the scientific outlook of the nineteenth century, which has not yet completely passed away. It will be noticed that much of the fundamental outlook of common sense has thus survived, though clarified and purified by a closer accord with facts. This scientific view retained unimpaired and indeed stressed with a new emphasis the things of common sense, matter, time and space, as well as all material or physical entities which are capable of observation or experimental verification. Nineteenth-century science is, in fact, a system of purified, glorified common sense. Its deterministic theory certainly gave a shock to the common man's instinctive belief in free will; in most other respects it conformed to the outlook of common sense. It is true that its practical inventions have produced the most astounding changes in our material civilization, but neither in its methods nor in its world-outlook was there anything really revolutionary.

But underneath this placid surface, the seeds of the future were germinating. With the coming of the twentieth century, fundamental changes began to set in. The new point of departure was reached when physical science ceased to confine its attention to the things that are observed. It dug down to a deeper level, and below the things that appear to the senses, it found, or invented, at the base of the world, so-called scientific entities, not capable of direct observa-

tion, but which are necessary to account for the facts of observation. Thus, below molecules and atoms still more ultimate entities appeared; radiations, electrons and protons emerged as elements which underlie and form our world of matter. Matter itself, the time-honored mother of all, practically disappeared into electrical energy.

> The cloud-capp'd towers, the gorgeous palaces,
> The solemn temples, the great globe itself:

yea, all the material forms of earth and sky and sea were dissolved and spirited away into the blue of energy. Outstanding among the men who brought about this transformation are two of my predecessors in this chair: Sir J. J. Thomson and Lord Rutherford. Like Prospero, like Shakespeare himself, they must be reckoned among the magicians.

Great as was this advance, it does not stand alone. Away in the last century, Clerk Maxwell, following up Faraday's theories and experiments, had formulated his celebrated equations of the electromagnetic field, which applied to light no less than to electromagnetism, and the exploration of this fruitful subject led Minkowski to the amazing discovery in 1908 that time and space were not separate things, but constituent elements in the deeper synthesis of space-time. Thus time is as much of the essence of things as space; it enters from the first into their existence as an integral element. Time is not something extra and superadded to things in their behavior, but is integral and basic to their constitution. The stuff of the world is thus envisaged as events instead of material things.

This physical concept or insight of space-time is our first revolutionary innovation, our first complete break with the old world of common sense. Already it has proved an instrument of amazing power in the newer physics. In the hands of an Einstein it has led beyond Euclid and Newton, to the recasting of the law and the concept of gravitation, and to the new relativity conception of the basic structure of the world. The transformation of the concept of space, owing to the injection into it of time, has destroyed the old passive homogeneous notion of space and has substituted a flexible, variable continuum, the curvatures and unevennesses of which constitute to our senses what we call a material world. The new concept has made it possible to construe matter, mass and energy as but definite measurable conditions of curvature in the structure of space-time. Assuming that electromagnetism will eventually follow the fate of gravitation, we may say that space-time will then appear as the scientific concept for the only physical reality in the universe, and that matter and energy in all their forms will have disappeared as independent entities and will have become mere configurations of this space-time. This will probably involve an amplified concept of space-time. Einstein has recently indicated that for further advance a modification in our space-time concept will become necessary, and that the additional element of direction will have to be incorporated into it. Whatever change may become necessary in our space-time concept, there can be no doubt about the immense possibilities it has opened up.

I pass on to an even more revolutionary recent advance of physics. The space-time world, however novel, however shattering to common sense, is not in conflict with reason. Indeed, the space-time world is largely a discovery of the mathematical reason and is an entirely rational world. It is a world where reason, as it were, dissolves the refractoriness of the old material substance and smooths it out into forms of space-time. Science, which began with empirical brute facts, seems to be heading for the reign of pure reason. But wait a bit; another fundamental discovery of our age has apparently taken us beyond the bounds of rationality, and is thus even more revolutionary than that of space-time. I refer to the quantum theory, Max Planck's discovery at the end of the nineteenth century, according to which energy is granular, consisting of discrete grains or quanta. The world in space-time is a continuum; the quantum action is a negation of continuity. Thus arises the contradiction, not only of common sense, but apparently also of reason itself. The quantum appears to behave like a particle, but a particle out of space or time. As Sir Arthur Eddington graphically puts it, a quantum of light is large enough to fill the lens of a hundred-inch telescope, but it is also small enough to enter an atom. It may spread like a circular wave through the universe, but when it hits its mark, this cosmic wave instantaneously contracts to a point where it strikes with its full and undivided force. Space-time, therefore, does not seem to exist for the quantum, at least not in its lower multiples. Nay, more: the very hitting of its mark presents another strange puzzle, which seems to defy the principles of causation and of the uniformity of nature, and to take us into the realm of chance and probability. The significant thing is that this strange quantum character of the universe is not the result of theory but is an experimental fact well attested from several departments of physics. In spite of the strange Puck-like behavior of the quantum, we should not lightly conclude, with some prominent physicists, that the universe has a skeleton in its cupboard in the shape of an irrational or chaotic factor. Our macroscopic concepts may not fit this ultra-microscopic world of the quantum. And our best hopes for the future are founded on the working out of a new system of concepts and laws suited to this new

world that has swum into the ken of science. The rapid development of wave mechanics in the last four years seems to have brought us within sight of this ideal, and we are beginning to discern a new kind of order in the microscopic elements of the world, very different from any type of law hitherto imagined in science, but none the less a rational order capable of mathematical formulation.

We may summarize these remarks by saying that the vastly improved technique of research has led to physical discoveries in recent years which have at last completely shattered the traditional common-sense view of the material world. A new space-time world has emerged which is essentially immaterial, and in which the old-time matter, and even the scientific mass, gravitation and energy stand for no independent entities, but can best be construed as configurations of space-time. And the discovery of the quantic properties of this world points to still more radical transformations which loom on the horizon of science. The complete recasting of many of our categories of experience and thought may ultimately be involved.

From the brilliant discoveries of physical science we pass on to the advances in biological science which, although far less revolutionary, have been scarcely less important for our world-outlook. The most important biological discovery of the last century was the great fact of organic evolution; and for this fact the space-time concept has at last come to provide the necessary physical basis. It is unnecessary for my purpose to canvass the claims and discuss the views represented by the great names of Lamarck, Darwin and Mendel, beyond saying that they represent a progressive advance in biological discovery, the end of which has by no means been reached yet. Whatever doubts and differences of opinion there may be about the methods, the mechanism or the causes, there is no doubt about the reality of organic evolution, which is one of the most firmly established results in the whole range of science. Paleontology, embryology, comparative anatomy, taxonomy and geographical distribution all combine to give the most convincing testimony that throughout the history of this earth life has advanced genetically from at most a few simple primitive forms to ever more numerous and highly specialized forms. Under the double influence of the internal genetic and the external environmental factors life has subtly adapted itself to the ever-changing situations on this planet. In the process of this evolution not only new structures and organs, but also new functions and powers have successively appeared, culminating in the master key of mind and in the crowning achievement of human personality. To have hammered the great truth of organic evolution into the consciousness of mankind is the undying achievement of Charles Darwin, by the side of which his discovery of natural selection as the method of evolution is of secondary importance.

The acceptance of the theory of evolution has brought about a far-reaching change in our outlook on the universe and our sense of values. The story of creation, so intimately associated with the groundwork of most religions, has thus come to be rewritten. The unity and interconnections of life in all its manifold forms have been clearly recognized. And man himself has had to come down from his privileged position among the angels and take his proper place in the universe as part of the order of nature. Thus Darwin completes the revolution begun by Copernicus.

Space-time finds its natural completion in organic evolution. For in organic evolution the time aspect of the world finds its most authentic expression. The world truly becomes process, where nothing ever remains the same or is a duplicate of anything else, but a growing, gathering, creative stream of unique events rolls forever forward.

But while we recognize this intimate connection between the conceptions of space-time and organic evolution, we should be careful not to identify the time of evolution with that of space-time. There is a very real difference between them. Biological time has direction, passes from the past to the future, and is therefore historical. It corresponds to the "before" and "after" of our conscious experience. Physical time as an aspect of space-time is neutral as regards direction. It is space-like, and may be plus or minus, but does not distinguish between past or future. It may move in either direction, backwards or forwards, while biological time, like the time of experience, knows only a forward flow. Hence cosmic evolution, as we see it in astronomy and physics, is mostly in an opposite direction to that of organic evolution. While biological time on the whole shows a forward movement towards ever higher organization and rising qualities throughout the geological ages, the process of the physical world is mostly in the opposite direction[2]—towards disorganization, disintegration of more complex structures and dissipation of energy. The second law of thermodynamics thus marks the direction of physical time. While the smaller world of life seems on the whole to be on the up-grade, the larger physical universe is on the down-grade. One may say that in the universe we witness a majority movement downward, and a minority movement upward. The energy which is being dissipated by the

[2] No doubt there are exceptions to this broad generalization. In astronomy stars and solar systems and galaxies are probably still being formed, while in physics syntheses of elements may possibly still be going on. In the same way we find in organic evolution minor phases of regression, degeneration and parasitism.

decay of physical structure is being partly taken up and organized into life structures—at any rate on this planet. Life and mind thus appear as products of the cosmic decline, and arise like the phoenix from the ashes of a universe radiating itself away. In them nature seems to have discovered a secret which enables her to irradiate with imperishable glory the decay to which she seems physically doomed.

Another striking point arises here. Organic evolution describes the specific process of what we call life, perhaps the most mysterious phenomenon of this mysterious universe. When we ask what is the nature of life we are curiously reminded of the behavior of the quantum referred to. I do not for a moment wish to say that the quantum is the physical basis of life, but I do say that in the quantum the physical world offers an analogy to life which is at least suggestive. The quantum follows the all-or-nothing law and behaves as an indivisible whole: so does life. A part of a quantum is not something less than a quantum; it is nothing or sheer nonentity: the same holds true of life. The quantum is perhaps most easily symbolized as a wave or combination of waves, which can only exist as a complete periodicity, and whose very concept negatives its existence as partial or truncated. In other words, it is a specific configuration and can only exist as such: the same holds true of life. The quantum does not fall completely within the deterministic causal scheme: the same seems true of life. Significant, also, is the fact that quantum phenomena underlie secondary qualities such as color and the like, which the older science in its mechanistic scheme ignored, but which are specially associated with life and consciousness. Apparently the quantum does not fall completely within the causal deterministic scheme: the same is true of life. Life is not an entity, physical or other. It is a type of organization; it is a specific principle of central or self-organization. If that organization is interfered with we are left, not with bits of life, but with death. The nature of living things is determined, not by the nature of their parts, but by the nature or principle of their organization. In short, the quantum and life seem to have this in common, that they both behave as wholes.

I have before now endeavored to explore the concept of life in the light of the more general concept of the whole. A whole is not a sum of parts, or constituted by its parts. Its nature lies in its constitution more than in its parts. The part in the whole is no longer the same as the part in isolation. The interesting point is that while this concept of the whole applies to life, it is according to the recent physics no less applicable to the ultimate physical units. Thus the electron within an atom is no longer a distinct electron. There may be separate electrons, but when they cease to be separate they also cease to be. The eight electrons which circulate in an oxygen atom are merged in a whole in such a way that they have lost their separate identity; and this loss of individuality has to be taken into account in calculations as to the physical behavior of the atom. The physicist, in fact, finds himself unable to look upon the entity which is one eighth of eight electrons as the same thing as a single electron. At the very foundation, therefore, of physics, the principle or category of the whole applies no less than in the advanced structure of life, although not in the same degree. In the ultimate analysis of the world, both at the physical and the biological level, the part or unit element somehow becomes shadowy and incoherent, and the very basis of mechanism is undermined. It would almost seem as if the world in its very essence is holistic, and as if the notion of individual parts is a practical makeshift without final validity in the nature of things.

The general trend of the recent advances in physics has thus been towards the recognition of the fundamental organic character of the material world. Physics and biology are beginning to look not so utterly unlike each other. Hitherto the great gulf in nature has lain between the material and the vital, between inorganic matter and life. This gulf is now in process of being bridged. The new physics, in dissolving the material world of common sense and discovering the finer structure of physical nature, has at the same time disclosed certain fundamental features which it has in common with the organic world. Stuff-like entities have disappeared and have been replaced by space-time configurations, whose very nature depends on their principle of organization. And this principle, which I have ventured to call holism, appears to be at bottom identical with that which pervades the organic structures of the world of life. The quantum and space-time have brought physics closer to biology. As I have pointed out, the quantum anticipates some of the fundamental characters of life, while space-time forms the physical basis for organic evolution. Physics and biology are thus recognized as respectively simpler and more advanced forms of the same fundamental pattern in world-structure.

The older mechanistic conception of nature, the picture of nature as consisting of fixed material particles, mechanically interacting with each other—already rudely shaken by the relativity theory—is now being modified by the quantum physics. The attack on mechanism, thus coming from physical science itself, is therefore all the more deadly. Even in physics, organization is becoming more important than the somewhat nebulous entities which enter into

matter. Interaction is more and more recognized to be not so much mechanical as organic or holistic, the whole in some respects dominating not only the functioning but the very existence of the entities forming it. The emergence of this organic view of nature from the domain of physics itself is thus a matter of first-rate importance, and must have very far-reaching repercussions for our eventual world-view.

The nature of the organic whole is, however, much more clearly recognized in its proper sphere of biology, and especially in the rapidly advancing science of physiology. Here, too, the correct view has been much obscured by the invasion of mechanistic ideas from the physics of the nineteenth century. A crude materialism all but swamped biology for more than a generation. At the Belfast session of this association in 1874 a famous predecessor of mine in this chair gave unrestained expression to this materialistic creed. All that is passing, if not already past. It must be admitted that up to a point mechanism has been useful as a first approximation and fruitful as a convention for research purposes. But if even in physics it has lost its savor, *a fortiori* has it become out of place in biology. The partial truth of mechanism is always subtended by the deeper truth of organicity or holism. So far from biology being forced into a physical mould, the position will in future be reversed. Physics will look to biology and even to psychology for hints, clues and suggestions. In biology and psychology it will see principles at work in their full maturity which can only be faintly and fitfully recognized in physics. In this way the exchanges of physics, biology and psychology will become fruitful for the science of the future, and lay the basis for a new scientific monism.

A living individual is a physiological whole, in which the parts or organs are but differentiations of this whole for purposes of greater efficiency, and remain in organic continuity throughout. They are parts *of* the individual, and not independent or self-contained units which *compose* the individual. It is only this conception of the individual as a dynamic organic whole which will make intelligible the extraordinary unity which characterizes the multiplicity of functions in an organism, the mobile, ever-changing balance and interdependence of the numerous regulatory processes in it, as well as the operation of all the mechanisms by which organic evolution is brought about. This conception applies not only to individuals, but also to organic societies, such as a beehive or an ants' nest, and even to social organizations on the human level.

As the concept of space-time destroys the purely spatial character of things, so the concept of the organic whole must also be extended beyond the spatial limits of the organism so as to include its interaction with its environment. The stimuli and responses which render them mutually interdependent constitute them one whole which thus transcends purely spatial aspects. It is this overflow of organic wholes beyond their apparent spatial limits which binds all nature together and prevents it from being a mere assemblage of separate interacting units.

It is time, however, that we pass on to the world of mind. From matter, as now transformed by space-time and the quantum, we pass step by step through organic nature to conscious mind. Gone is the time when Descartes could divide the world into only two substances: extended substance or matter, and thinking substance or mind. There is a whole world of gradations between these two limits. On Descartes' false dichotomy the separate provinces of modern science and philosophy were demarcated. But it is as dead as the epicycles of Ptolemy, and ultimately the Cartesian frontiers between physics and philosophy must largely disappear, and philosophy once more become metaphysic in the original sense. In the meantime, under its harmful influence, the paths of matter and mind, of science and philosophy, were made to diverge farther and farther, so that only the revolution now taking place in thought could bring them together again. I believe, however, their reunion is coming fast. We have seen matter and life indefinitely approaching each other in the ultimate constituents of the world. We have seen that matter is fundamentally a configuration or organization of space-time; and we have seen that life is a principle of organization whereby the space-time patterns are arranged into organic unities. The next step is to show that mind is an even more potent embodiment of the organizing whole-making principle, and that this embodiment has found expression in a rising series, which begins practically on the lowest levels of life, and rises ultimately to the conscious mind which alone Descartes had in view in his classification. I have no time to follow up the matter here beyond making a few remarks.

Mind is admittedly an active, conative, organizing principle. It is forever busy constructing new patterns of things, thoughts or principles out of the material of its experience. Mind, even more than life, is a principle of whole-making. It differentiates, discriminates and selects from its vague experience, and fashions and correlates the resulting features into more or less stable, enduring wholes. Beginning as mere blind tropisms, reflexes and conditioned reflexes, mind in organic nature has advanced step by step in its creative march until in man it has become nature's supreme organ of understanding, endeavor and control—not merely a subjective human organ, but

nature's own power of self-illumination and self-mastery—"The eye with which the universe beholds itself and knows itself divine."

The free creativeness of mind is possible because, as we have seen, the world ultimately consists, not of material stuff, but of patterns, of organization, the evolution of which involves no absolute creation of an alien world of material from nothing. The purely structural character of reality thus helps to render possible and intelligible the free creativeness of life and mind, and accounts for the unlimited wealth of fresh patterns which mind freely creates on the basis of the existing physical patterns.

The highest reach of this creative process is seen in the realm of values, which is the product of the human mind. Great as is the physical universe which confronts us as a given fact, no less great is our reading and evaluation of it in the world of values, as seen in language, literature, culture, civilization, society and the state, law, architecture, art, science, morals and religion. Without this revelation of inner meaning and significance the external physical universe would be but an immense empty shell or crumpled surface. The brute fact here receives its meaning, and a new world arises which gives to nature whatever significance it has. As against the physical configurations of nature we see here the ideal patterns or wholes freely created by the human spirit as a home and an environment for itself.

Among the human values thus created science ranks with art and religion. In its selfless pursuit of truth, in its vision of order and beauty, it partakes of the quality of both. More and more it is beginning to make a profound esthetic and religious appeal to thinking people. Indeed, it may fairly be said that science is perhaps the clearest revelation of God to our age. Science is at last coming into its own as one of the supreme goods of the human race.

While religion, art and science are still separate values, they may not always remain such. Indeed, one of the greatest tasks before the human race will be to link up science with ethical values, and thus to remove grave dangers threatening our future. A serious lag has already developed between our rapid scientific advance and our stationary ethical development, a lag which has already found expression in the greatest tragedy of history. Science must itself help to close this dangerous gap in our advance which threatens the disruption of our civilization and the decay of our species. Its final and perhaps most difficult task may be found just here. Science may be destined to become the most effective drive towards ethical values, and in that way to render its most priceless human service. In saying this I am going beyond the scope of science as at present understood, but the conception of science itself is bound to be affected by its eventual integration with the other great values.

I have now finished my rapid and necessarily superficial survey of the more prominent recent tendencies in science, and I proceed to summarize the results and draw my conclusions, in so far as they bear on our world-picture.

In the first place we have seen that in the ultimate physical analysis science reaches a microscopic world of scientific entities, very different in character and behavior from the macroscopic world of matter, space and time. The world of atoms, electrons, protons, radiations and quanta does not seem to be in space-time, or to conform to natural law in the ordinary sense. The behavior of these entities can not be understood without the most abstruse mathematics, nor, apparently, without resort to epistemological considerations. We seem to have passed beyond the definitely physical world into a twilight where physics and metaphysics meet, where space-time does not exist, and where strictly causal law in the old sense does not apply. From this uncertain nebulous underworld there seems to crystallize out, or literally to materialize, the macroscopic world which is the proper sphere of sensuous observation and of natural laws. The pre-material entities or units condense and cohere into constellations, which increase in size and structure until they reach the macroscopic stage of observation. As the macroscopic entities emerge, their space-time field and appropriate natural laws (mostly of a statistical character) emerge *pari passu*. We seem to pass from one level to another in the evolution of the universe, with different units, different behaviors—and calling for different concepts and laws. Similarly, we rise to new levels as later on we pass from the physical to the biological level, and again from the latter to the level of conscious mind. But—and this is the significant fact—all these levels are genetically related and form an evolutionary series; and underlying the differences of the successive levels, there remains a fundamental unity of plan or organization which binds them together as members of a genetic series, as a growing, evolving, creative universe.

In the second place let us see how common sense deals with this macroscopic world. On this stage common sense recognizes three levels of matter, life and mind as together composing the world. But it places them so far apart and makes them so inherently different from each other that relations between them appear unintelligible, if not impossible. The common-sense notions of matter, life and mind make any relations between them, as well as the world which they form, an insoluble puzzle. The older science there-

fore attempted to reduce life substantially to terms of matter, and to put a question mark behind mind; and the result was a predominantly materialistic view of the world. The space-time relativity concept of the world has overcome the difficulty by destroying the old concept of matter, and reducing it from a self-subsistent entity to a configuration of space-time —in other words, to a special organization of the basic world-structure. If matter is essentially immaterial structure or organization, it can not fundamentally be so different from organism or life, which is best envisaged as a principle of organization; nor from mind, which is an active organizer. Matter, life and mind thus translate roughly into organization, organism, organizer. The all-or-none law of the quantum, which also applies to life and mind, is another indication that matter, life and mind may be but different stages or levels of the same activity in the world which I have associated with the pervading feature of whole-making. Materialism has thus gone by the board, and the unintelligible trinity of common sense (matter, life, mind) has been reinterpreted and transformed and put on the way to a new monism.

In the third place, the iron determination of the older science, so contrary to direct human experience, so destructive of the free activity of life and mind, as well as subversive of the moral responsibility of the individual, has also been materially recast. It was due to the Newtonian causal scheme which, as I have indicated, has been profoundly shaken by recent developments. Relativity reduces substance to configuration or patterns, while quantum physics gives definite indications of indeterminism in nature. In any case, life through the ages shows clearly a creative advance to ever more complex organization, and ever higher qualities, while mind is responsible for the creation of a whole realm of values. We are thus justified in stressing, along with natural necessity, an increasing measure of freedom and creativeness in the world, sufficient at least to account for organic evolution and for the appearance of moral law and endeavor. This liberation of life and spirit from the iron rule of necessity is one of the greatest gains from the recent scientific advances. Nature is not a closed physical circle, but has left the door open to the emergence of life and mind and the development of human personality. It has, in its open flexible physical patterns, laid the foundation and established the environment for the coming of life and mind. The view, to which Huxley once gave such eloquent and poignant expression, of a dualism implanted in the heart of nature, of a deadly struggle between cosmic law and moral law, is no longer justified by the subsequent advances of science.

But, in the fourth place, another dualism of a wider reach has appeared, which makes the universe itself appear to be a house divided against itself. For while the stream of physical tendency throughout the universe is on the whole downward, toward disintegration and dissipation, the organic movement, on this planet at least, is upward, and life structures are on the whole becoming more complex throughout the course of organic evolution. From the viewpoint of physics, life and mind are thus singular and exceptional phenomena, not in line with the movement of the universe as a whole. Recent astronomical theory has come to strengthen this view of life as an exceptional feature off the main track of the universe. For the origin of our planetary system is attributed to an unusual accident, and planets such as ours with a favorable environment for life are taken to be rare in the universe. Perhaps we may even say that at the present epoch there is no other globe where life is at the level manifested on the earth. Our origin is thus accidental, our position is exceptional, and our fate is sealed, with the inevitable running down of the solar system. Life and mind, instead of being the natural flowering of the universe, are thus reduced to a very casual and inferior status in the cosmic order. A new meaning and a far deeper poignancy are given to Shakespeare's immortal lines:

> We are such stuff
> As dreams are made of; and our little life
> Is rounded with a sleep.

According to astronomy, life is indeed a lonely and pathetic thing in this physical universe—a transient and embarrassed phantom in an alien, if not hostile, universe.

Such are some of the depressing speculations of recent astronomical theory. But in some respects they have already been discounted in the foregoing. For even if life be merely a terrestrial phenomenon, it is by no means in an alien environment if, as we have seen reason to think, this is an essentially organic universe. In its organic aspects the universe is on the way to life and mind, even if the goal has been actually reached at only one insignificant point in the universe. The potencies of the universe are fundamentally of the same order as its actualities. The universe might say in the words of Rabbi Ben Ezra:

> All I could never be
> All man ignored in me,
> This I was worth to God.

Then again, the very possibility of perception, of knowledge and science depends on an intimate relation between mind and the physical universe. Only thus can the concepts of mind come to be a measure for the facts of the universe, and the laws of nature come

to be revealed and interpreted by nature's own organ of the human mind. Besides science we have other forms of this inner relation between the mind and the universe, such as poetry, music, art and religion. The human spirit is not a pathetic wandering phantom of the universe, but is at home, and meets with spiritual hospitality and response everywhere. Our deepest thoughts and emotions and endeavors are but responses to stimuli which come to us, not from an alien, but from an essentially friendly and kindred universe. So far from the cosmic status of life and mind being degraded by the newer astronomy and physics, I would suggest an alternative interpretation of the facts, more in accord with the trend of evolutionary science. We have seen a macroscopic universe born or revealed to consciousness out of a prior microscopic order of a very different character. Are we not, in the emergence of life and mind, witnessing the birth or revelation of a new world out of the macroscopic physical universe? I suggest that at the present cosmic epoch we are the spectators of what is perhaps the grandest event in the immeasurable history of our universe, and that we must interpret the present phase of the universe as a mother and child universe, still joined together by a placenta which science, in its divorce from the other great values, has hitherto failed to unravel.

Piecing together these clues and conclusions we arrive at a world-picture fuller of mystery than ever. In a way it is closer to common sense and kinder to human nature than was the science of the nineteenth century. Materialism has practically disappeared, and the despotic rule of necessity has been greatly relaxed. In ever varying degree the universe is organic and holistic through and through. Not only organic concepts, but also, and even more so, psychological viewpoints are becoming necessary to elucidate the facts of science. And while the purely human concepts, such as emotion and value, purpose and will, do not apply in the natural sciences, they retain their unimpaired force in the human sciences. The ancient spiritual goods and heirlooms of our race need not be ruthlessly scrapped. The great values and ideals retain their unfading glory and derive new interest and force from a cosmic setting. But in other respects it is a strange new universe, impalpable, immaterial, consisting not of material or stuff, but of organization, of patterns or wholes which are unceasingly being woven to more complex or to simpler designs. In the large it appears to be a decaying, simplifying universe which attained to its perfection of organization in the far-distant past and is now regressing to simpler forms—perhaps for good, perhaps only to restart another cycle of organization. But inside this cosmic process of decline we notice a smaller but far more significant movement—a streaming, protoplasmic tendency; an embryonic infant world emerging, throbbing with passionate life, and striving towards rational and spiritual self-realization. We see the mysterious creative rise of the higher out of the lower, the more from the less, the picture within its framework, the spiritual kernel inside the phenomenal integuments of the universe. Instead of the animistic, or the mechanistic, or the mathematical universe, we see the genetic, organic, holistic universe, in which the decline of the earlier physical patterns provides the opportunity for the emergence of the more advanced vital and rational patterns.

In this holistic universe man is in very truth the offspring of the stars. The world consists not only of electrons and radiations, but also of souls and aspirations. Beauty and holiness are as much aspects of nature as energy and entropy. Thus "in eternal lines to time it grows." An adequate world-view would find them all in their proper context in the framework of the whole. And evolution is perhaps the only way of approach to the framing of a consistent world-picture which would do justice to the immensity, the profundity and the unutterable mystery of the universe.

Such in vague outline is the world-picture to which science seems to me to be pointing. We may not all agree with my rendering of it, which indeed does not claim to be more than a mere sketch. And even if it were generally accepted, we have still to bear in mind that the world-picture of to-morrow will in all probability be very different from any which could be sketched to-day.

SCIENTIFIC EVENTS

THE NATIONAL METAL CONGRESS

The Review, official journal of the American Society for Steel Treating, reports the meeting of the National Metal Congress at Boston, from September 21 to 25. The Institute of Metals and the Iron and Steel Divisions of the American Institute of Mining and Metallurgical Engineers met jointly at the Hotel Statler.

The officers of the Institute of Metals Division were: Sam Tour, *chairman;* Zay Jeffries, *past chairman;* J. R. Freeman, Jr., and C. H. Mathewson, *vice-chairmen,* and William M. Corse, *secretary-treasurer.* John L. Christie and E. M. Wise, respectively chairman and vice-chairman of the papers and publications committee of the division, were active in organizing the technical program for the meeting. The