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THE UNIVERSE AS A WHOLE[1]

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In Nature's infinite book of secrecy
A little I can read
—*Antony and Cleopatra*

THINKING COSMICALLY

MOST men to-day are engrossed in some one particular profession or occupation, that may involve monotonous drudgery, or may require special skill, technical knowledge, long experience and, more rarely, profound thought.

But it is doubtful if any group of men, except perhaps a few philosophers, is engaged in fitting together the jig-saw or patchwork puzzle of the multitudinous discoveries and theories of all our diverse branches of knowledge. Thought is thus divided into water-tight compartments, between which the communications are blocked.

Indeed, the further question arises whether the different parts of the puzzle will, in the present state of our knowledge, fit together at all; whether the gaps and misfits are not too wide and too great to permit of the undertaking. It is pertinent to remark that many of the great advances to-day are made by those who are fortunate and able enough to be expert in two subjects, for example, in physics and in physiology, or in mathematics and physics, or in physics and chemistry, or in physics and philosophy. Borderlands are prolific.

There is a further difficulty in finding a man with a sufficiently catholic taste to consider all the realms of knowledge as a unity. Who indeed is equipped mentally for such a giant's task? Who can say nowadays with Bacon that he "takes all knowledge for his province"?

Certainly not the present writer! The fitness rather rests with the audience, for the Royal Society of

[1] Presidential address before the Royal Society of Canada, given on May 20, 1930.

Canada consists of men carefully selected for their achievements, as authors, poets, historians, statesmen and as savants of every branch of natural science, the very list of which it would be tedious to recite. These men, too, belong to at least two types of Western European civilization, crudely summarized as English and French, including our inheritance from Greece and from Rome.

Perhaps then we are justified in following the advice of Fitzgerald, "to think cosmically," and to contemplate the universe as a whole.

THE FRAMEWORK OF THE MACROCOSM

We find scattered through a vast region, nebulae, stars, planets, moons, comets, meteors, dust, gases and their radiations, with the main masses, the stars, far apart compared with their size, dominated by a mutual attraction, all in motion with respect to each other. There is there no such thing as rest. All these stars move with velocities ranging from a few miles a second to a few hundred miles a second. There is no suggestion of a very high gravitational potential; in simpler words, we see no evidence of an infinite, but rather of a large finite amount of matter in the universe.

Between these bodies there exists, or our intelligence infers from experience, a space approximately Euclidean, where the three angles of a triangle certainly do equal two right angles very nearly indeed.

This space has remarkable physical properties inasmuch as waves of a common nature pass swiftly in all directions freely, without interfering with one another's progress, differing, however, in wave-length, and all having the well-known high speed of light. This velocity appears to be one of the great constants of nature, which may be regarded not as relative, but as independent of the velocity of the source and of the speed of the observer. Space, then, is the region or vehicle of radiant energy. Since we know, or conjecture, that all matter is but one form of energy we can estimate energy in terms of mass, and we may even quote the price of radiant energy in pounds in place of kilowatt-hours, and calculate the quantity received by the earth from the sun. The price is high and the quantity large. The earth receives from the sun about 160 tons of sunlight a day, to a value of 500 million dollars a pound, so that our power bill amounts to 150 million million dollars a day, reckoned on the basis at which we have to buy our electricity in Montreal. This power bill is of course never presented, and our power-house, the sun, has been running effectively and regularly for at least ten thousand million years, and is likely to run, bar unforeseen accidents, for as many years at least in the future. We will postpone for the present the question of its closing-down!

This great space through which radiant energy passes may be regarded as empty or, inasmuch as it has the wonderful property of transmitting power, we may consider it as a physical entity, deem it worthy of a name and continue to call it ether, remembering always that in practice we give names to those things which have observable properties or distinguishable attributes. Apparently we must entirely divest our minds of all material ideas when we speak of the ether, but this will trouble us less and less as we continue to strip matter itself more and more of material attributes, and focus our attention on the less palpable manifestation of energy. Not that it is suggested that the word spiritual would at all help us in our idea of ether, nor can we find any warrant in fact, so far as present knowledge and experience seem to go, that the ether is the seat of psychic forces of a non-physical character. Any confusion between these ideas is at present the reverse of helpful, but even if the properties of the ether are one thing, and the properties of matter another, yet the linkage between them is so intimate that it may be that matter is merely a local singularity or peculiar structure of ether, as Sir Joseph Larmor and others have suggested.

At present it is still convenient to think of the universe as consisting, physically, of matter and of ether, or if you please, of two different forms of energy, matter and radiation alike passing through space.

SPACE

If, as is the fashion to-day, we are relativists, we can believe that our space is finite but unbounded, and we are at liberty to agree with Silberstein that no distance greater than nine million light-years is measurable in our universe. This leaves ample room for most of us, but it may be that some astronomers will feel themselves sadly cramped in so narrow a space, and indeed they now speak of distance exceeding a hundred million light-years.

To some degree it exalts the importance of each individual to realize that each one is the center of his own universe wherever he be, and however fast he may move. Every man has his own ether, just as every man has his own rainbow. All the signals of nature which we receive by our senses and interpret by our minds are of course different for each individual.

Speculations as to space and ether have a powerful fascination, but our actual knowledge is summed up by such ideas as Faraday's lines and fields of force, and more precisely by Maxwell's equations for elec-

tromagnetic fields. It was the effort to verify the truth of these equations which led Hertz to discover wireless (or radio) waves which enter to-day so largely into human life and experience.

THE MICROCOSM

As we find that the universe may be bounded in its size as regards greatness, so we may ask whether there is any limit in the other direction, whether there is any limit as to the possible smallness of an entity, and although the time is not yet ripe to speak definitely on this question, yet we shall see shortly that there may indeed be some limitation of the kind which I have suggested.

First let us, however, return to our suns, planets and moons, and realize that they are all made out of the same stuff, and of the very same elements with which we are familiar on this earth. This common material suggests, does it not, a very thorough mixing together in the past? The stars, each one of them, go through a regular prolonged stage of evolution, so that a glance at a star's spectrum, taken with telescope and prism, immediately informs the trained observer whether that star is in glorious growth, comfortable middle age or finally in the autumn of life or senile decay. Those stars which have reached their winter may be invisible to us, dark stars whose only chance, and that exceedingly remote, of a continuance of activity is a collision with a traveling neighbor.

The material of the universe everywhere consists of ninety-two elements, and it is now known that there remain only two or three to be discovered, unless there are some heavier than uranium. These elements are the bricks of which the great edifice is composed throughout. They exist rather permanently as atoms, except in one great group of radioactive atoms, which spontaneously disrupt and become new atoms. Some of the elemental atoms have also been deliberately broken up, by careful design, as when Rutherford knocked hydrogen nuclei out of nitrogen, using alpha particles of radium as his Big Bertha or Roaring Megs. This control of atoms and their behavior tells a very different story from the nineteenth century idea of hard, elastic, everlasting and indivisible atoms.

Atoms are wont to link together by bonds invisible and unknown (probably electromagnetic) and to combine into molecules, sometimes simple, and at other times, as in vegetables and animals, of appalling complexity. The simplest plant is a complex and marvelous chemical factory, which can also give birth to other similar factories! In the simpler cases it would at first appear probable that we could say—a molecule of water consists of two atoms of hydrogen and one atom of oxygen. We know the properties of both these constituent gases, therefore we can deduce the properties of the water molecule, and can foretell all the chemical and physical behavior of ice, water and steam. I need hardly tell you how immensely short we fall of this achievement at present, yet it is a perfectly reasonable goal towards which to strive. The matter is of such profound philosophical importance that it may be wise to dwell on it longer. The behavior of the hydrogen atom is well known, but is it possible to deduce the properties of the hydrogen molecule, which is two atoms in close partnership? Here we have the most direct and simple problem of physico-chemistry, and yet it turns out to be terribly complex; indeed men are spending a large part of their lives on such apparently simple problems. It seems that from two simple entities there is created, or there evolves, a quite new and different complex or entity. Surely there is some satisfaction to the biologists in this situation! We may use the dubious phrase "creative evolution," but the wonder is not that new forms arise; the larger mystery is how species are preserved, and how it is possible for offspring remotely to resemble their parents and ancestors!

To return to the molecules—after formation they are usually in a dynamic state, with their atoms oscillating to and fro, or revolving around one another, or both. The molecules may at the same time be rushing about with the velocity of bullets as in a gas, frequently colliding and rebounding, or they may jostle one another about in that crowded state we call a liquid, of which motion there is good evidence in the Brownian movement.

Yet again the molecules may, like men in a well-drilled army, fall into rank after rank of orderly arrangement so that there is a crystal, coherent, solid! The study of crystals has occupied, and is occupying, the lives of many of the ablest men in the world. In the great harmony of crystal arrangement there is to the human mind a satisfaction found elsewhere perhaps only in mathematics and in music.

ATOMS AND ELECTRONS

Hunting further in the microcosm we find physicists restless in the pursuit of the interior constitution of the atom. The genius of J. J. Thomson, Rutherford, Moseley, Bohr and others has drawn back the veil even in the lifetime of most of us, so that we find the bulk of the weight, mass or substance of an atom concentrated at the very nucleus or inner citadel, as a positive charge of electricity, this nucleus being small indeed compared with the whole atom. Around the nucleus we had a most satisfying picture or model of a swarm of electrons from one to ninety-two,

according to the number of the atom, going swiftly around in elliptic orbits somewhat as planets go around our sun, with the most disconcerting added behavior that these electrons could leap from one orbit to another according to well-conceived plan or rule, totally at variance with all our previous knowledge of how well-ordered bodies should behave. Hence the great quantum theories which so greatly perturb old-fashioned physicists, who have to face a revolution in their electrodynamic conceptions when they endeavor to apply them to the constituent parts of an atom. It is curious to note that the principle of relativity has greatly attracted the attention of the thinking public, while the far greater *bouleversement* of quantum mechanics has hardly yet received attention.

At any rate, in place of the ninety-two elements in the universe, we enthrone two and only two physical entities—protons and electrons—together with the radiations or electromagnetic waves which pass through space between them, for every atom is both a wireless broadcasting station and also a wireless receiving station between which energy exchanges take place only in definite "lumps," each lump, bundle or quantum strictly proportional to the frequency transmitted; in other words, the illusive action is strictly atomic; or the ultimate "energy-time" is indivisible, a real atom. This sublimely simple electronic theory of the universe is now the fundamental common stock of all physicists, and provides sufficient and reasonable foundation for all purely physical phenomena. Yet it has been realized that the picture is too crude, and that there is either a limit to our perception or a limit set by nature herself, so that authorities like Bohr, Heisenberg, Schrödinger and Dirac assure us that we must abandon all models, all diagrams, all our large-scale experience, whether suns, planets or billiard balls, and admit that the microcosm does *not* resemble the macrocosm: that of the electron we can never say, Lo! here it is! It has gone before we say it. To mention its speed is to lose its position, or to indicate its place is to confound its speed. This is profoundly disconcerting to those, who, like the writer, have been brought up to revel in models and lines of force and diagrams. Only mathematical equations, complicated enough, expressing wave motions, can now describe the behavior of atoms and electrons. Only the probability can be calculated of the place or motion of individual electrons. The physicist stands as actuary calculating the statistical behavior of a crowded and confused entity. That there will be a reaction to these tendencies is most probable, perhaps led by plain-thinking Anglo-Saxons; but whether the reaction will be the more successful is quite another question. *Magna est veritas, praevalebit!*

Our satisfaction in the present physical outlook is further modified by two points. In the first place, we can not pretend to give any explanation of electricity or of electrical energy in terms of anything more simple or fundamental, so that there is still no bottom found to the deep well of truth. In the second place, when we are confronted with questions as to the origin and the enduring qualities of things we have no physical suggestion whatever, not the vaguest guess, to offer in reply. Two of the most important movements of to-day are these. The insistence that science must confine its attention to observable and measurable quantities, thus sharply separating physics from speculative metaphysics; and secondly the growing possibility that the search for the ultimate nature of substance is futile and, like perpetual motion machines, may be safely abandoned. Effort is concentrated on the structure, on the form, arrangement and resulting habits or behavior of things. Thus the appeal to models is passing away, and the trust in mathematical symbols, equations and deductions is growing stronger.

Personally I flatly rebel against all trammels and I advocate complete freedom in attacking all problems by any means available. When the key is lost, smash the lock and force the cupboard; and when the front stairs are blocked, try the back or a ladder outside. The work of many Anglo-Saxons has been of this direct and practical character, and it has proved singularly fruitful in face of difficulties. If Maxwell had been restrained, would his imaginative genius have produced his great treatise on electricity?

AGE OF THE UNIVERSE

There is clearly stamped on the universe a great but not an infinite antiquity. By all the known laws of physics the universe is a going concern, perhaps in middle age, which has not gone on forever and will not continue forever.

Two great tenets of science have been (1) the conservation of mass, the foundation of chemistry, and (2) the conservation of energy, the foundation of physics. It now appears probable, from the physics of the stars, that matter can cease to exist as such and give birth to a precisely equivalent amount of radiant energy. There is diligent search for the reciprocal transformation, whereby the continual outpourings of light and heat, radiating from all the stars and spreading into empty space, may again collect and reorganize into electrons, protons and atoms. No such changes are at present discernible.

Newton's queries in his "Optics" had some premonition of such energy changes:

> Are not gross Bodies and Light convertible into one another, and may not Bodies receive much of their Activity from the Particles of Light which enter into their composition?

The changes of Bodies into Light and Light into Bodies is very comformable to the Course of Nature which seems delighted with Transmutation.

To-day this statement simply becomes, following Einstein,

$$E = Mc^2$$

where E is the energy, M is the mass and c the great constant, the velocity of light. By this equation we can express mass as energy, grams as ergs, or pounds as foot-pounds, or the converse.

It is not, however, the question of the annihilation of matter or the elimination of energy with which we are now concerned; rather it is the well-known fact that energy tends to become degraded or unavailable. All power machines and all life depend ultimately upon a source of heat relative to a cooler environment. Old age brings on that feebleness of energy which is no longer available when all has reached a dead level. There can not be water-power when the land is all at sea-level. Nor can you grind corn with water that has passed the mill! Unless indeed as now the beneficent rays of the sun, falling on the wide bosom of land and sea, lift again that water into the moving clouds to send a gracious rain on our inheritance. Many attempts have been made to remove this rather dismal picture of a worn-out universe from our imagination. Heat-death, it may be called.

The physical universe is proceeding, not to ruin, but to a dull uniformity. The energy will still be conserved, but it is becoming less and less available either for doing work or for sustaining life.

Had not Newton some conception of this question of the degradation of energy when he wrote the thirtieth query in his "Optics"?—"Motion is much more apt to be lost than to be got."

Jeans states that

> Everything points with overwhelming force to a definite event, or series of events, of creation at some time or times, not infinitely remote. . . . The universe can not have originated by chance out of its present ingredients, and neither can it always have been the same as now. For in either of these events no atoms would be left save such as are incapable of dissolving into radiation; there would be neither sunlight nor starlight, but only a cool glow of radiation uniformly diffused through space. This is, indeed, so far as present-day science can see, the final end towards which all creation moves, and at which it must at long last arrive.

Let us admit that "as far as present-day science can see" at the long last there are to remain some dead stars, some inert atoms and "the cool glow of radiation uniformly diffused through space," which must, of course, be perpetual, everlasting, devoid of change.

But does anybody seriously believe that?

Jeans himself admits that everything points with overwhelming force to a definite event, or series of events, of *creation* at some time or times, not infinitely remote. Where there is creation, then there is purpose. Where there has once been purpose, there may be continuation of purpose, or a recurrence of purpose. So also if there was once creation there may be a continuance of creation or a fresh creation. Eliminate purpose and there is no creation and no beginning to the physical universe. At what stage then can purpose be eliminated? This question is not now popular, and the word "teleology," meaning purpose, or direction towards an end in view, is largely taboo in science to-day. But why?

This tendency of energy towards decadence was never more exquisitely stated than in the "Tempest," when Prospero, after showing his vision, exclaims:

> These our actors,
> As I foretold you, were all spirits, and
> Are melted into air, into thin air:
> And, like the baseless fabric of this vision,
> The cloud-capp'd towers, the gorgeous palaces,
> The solemn temples, the great globe itself,
> Yea, all which it inherits, shall dissolve,
> And, like this insubstantial pageant faded,
> Leave not a rack behind. We are such stuff
> As dreams are made on; and our little life
> Is rounded with a sleep.

After which he begs us—

> Bear with my weakness; my old brain is troubled.

Well! Troy, Babylon, Carthage, have gone and we do not greatly lament them, and shall our turn not come? "Heraclitus is dead; and he was a better man than thou!"

Where we now are there was a sheet of ice perhaps four thousand feet thick. The ice will come again, and perchange go again, but ultimately it will remain.

And yet the full tide of pessimism has not been fathomed, for consider the words of Bertrand Russell in "Mysticism and Logic":

> That man is the product of causes which had no prevision of the end they were achieving; that his origin, his growth, his hopes and fears, his loves and his beliefs are but the outcome of accidental collocations of atoms; that no fire, no heroism, no intensity of thought and feeling can preserve an individual life beyond the grave; that all the labours of all the ages, all the devotion, all the inspiration, all the noonday brightness of human genius are destined to extinction in the vast death of the solar system, and that the whole temple of man's achievement must inevitably be buried beneath the debris of a universe in ruins—all these things, if not quite beyond dispute, are yet so nearly certain that no philosophy which rejects them can hope to stand.

Here indeed we have the very quintessence of ultra-pessimism. But as the man who tried to be a philosopher said to Dr. Johnson, "Cheerfulness will keep breaking through." Nobody need believe these things unless he likes; indeed we do not really know all this.

For another great philosopher, Whitehead, writes, "The fact of the religious vision and its history of persistent expansion is our one ground of optimism. Apart from it, human life is a flash of occasional enjoyment, lighting up a mass of pain and misery, a bagatelle of transient experience." But even this optimism has a decidedly neutral tint. The fact is that we are in a period of great flux and change, still under the shadow of the great war and its gloomy aftermath. It is the glory, the privilege and the responsibility of the present generations that they have immense new problems to solve. If we conform to the narrow limitations of a purely mechanical outlook, we shall never see the wood for the trees, and we shall reap as we sow. If the greater qualities are brought into play, then there may be success! What are these qualities? Dean Inge has compactly described them—"truthfulness, courage, justice and fair play, abhorrence of meanness and crooked dealing, and respect for all human beings as such."

The tendencies that we observe in a long period of time are really ephemeral; a fly, living but for a day, can not hope to detect the motion of the planet Neptune. It was a fly too in the fable, that, seated on a chariot wheel, exclaimed, "See! what a dust do I stir!"

Perhaps we should never say that at some distant date the universe was created; rather let us say, the universe is now being created, and insist that at all times such a statement has been true. Shall we add with Walt Whitman that the universe was never more perfect than it is now, and conclude with Marcus Aurelius, "Could he say of Athens, Thou lovely city of Cecrops, and shalt thou not say of the world, Thou lovely city of God?"

TIME

Like other entities time is a matter of experience. To the mathematician time is readily reversible, but in experience the past and the future are sharply distinguished. I can actually go to California and back, but not to last week and back, except in memory.

Yet if I go to California I must expend time to cover space; nor is my journey direct, but to right or left, and up and down, added to the actual distance, so that we have three degrees or types of space linked to one of time, and Minkowski brilliantly showed us how inevitably these were united in the four-fold union of space-time.

It has always seemed to me that even in this four-dimensional union something is still lacking. In order to go to California I must have money, an important fifth degree of freedom. It is well known, however, that money is merely the opportunity to acquire what we think that we need, and on a journey money buys energy, so requisite for the traveler's life and movement, and no less essential to the army of workers who to-day assist him on his journey whether by direct or mechanical means. A bird can obtain its energy directly from food, and requires no money for sustenance, clothes or transportation.

The fifth degree of freedom is, therefore, energy, and a large part of it we derive from breathing air, the only thing still free to all, without taxation or payment.

It is a remarkable fact that, in physics, energy has an intimate relation with time, and also with frequency; so that it is a particular fad of the author to endeavor to ascertain to what extent we can substitute the frequency of waves for the perhaps less tangible, but more familiar, concept of energy. This is scarcely the place to enlarge on this idea; and it must suffice to point out that, as Einstein explained gravitation on a geometrical basis, so it may be possible to consider energy more fully as an aspect of frequency, possibly arriving at a comprehensive wave theory of the universe.

Eddington in his "Nature of the Physical Universe" sets forth a fascinating picture of the inevitable unidirectional progress of time, as almost embedded in nature. The second law of thermodynamics, the running down of the universe as if it were a clock, with the gradual degradation and unavailability of energy, are picturesquely referred to as "time's arrow." The fact that certain processes in nature can not be reversed may lead to the result that time can not be reversed. To an intelligence higher than our own, time past, present and future might conceivably have a oneness quite foreign to our experience, but not perhaps beyond the imagination of a mathematician.

LIFE

So far we have considered matter apart from life. All the difficulties hitherto encountered become intensified by a new factor, which can not even be defined, when we consider living things. To suggest that life is merely mechanism is to confuse two terms with quite different meanings. Machines are contrived from without, but living things are organized from within, and we can not definitely demonstrate either conscious purpose or intelligent directing mind. Yet we do see the most marvelous coordination of the whole, due to the cooperation of the constituent parts. I am speaking of such things as trees and bees, and of many happenings within our own bodies. Were

these events left to our conscious and intelligent selves, then our lives would not be prolonged for a minute. We have not intelligence enough to manage even a minute part of our bodies for a small fraction of a second. For example, who of us all would dare to assume complete responsibility for the output of new blood corpuscles, or for the necessary continual repairs, say, to his eye?

If a man breaks a leg, nature repairs it for him. Who and what is this nature?

> Nature is neither kernel nor husk—she is everything at once.
>
> —*Goethe*

> Nature is at once a *science* which never leaves off deducing effects from causes and an *art* which without end exercises itself in new inventions.
>
> —*Lachelier*

> Nature is now no more—even to the scientific thinker—a mechanical contrivance like a complicated and highly ingenious machine. . . . Nature is—what it always has been to the common sense view—a texture in which the mechanical warp is shot through everywhere by the spiritual woof.
>
> —*Merz, modified from William Jones*

That living creatures are constructed of matter no one will for a moment dispute; that there are, in life, transferences of energy which fully obey the laws of physics and chemistry no one will deny, but to insist that these laws or theories, as we now know them or even as they may develop, impose a necessary limitation to our conception of life, or to regard them even remotely as causation, is a step quite unwarrantable. What then do we need to add? There is nothing to suggest! But because no answer is at present forthcoming we can not assume that an answer is forever impossible. No doubt one important factor is the organization as a whole, which is not merely a sum of its parts.

The pretty quarrel between mechanists and vitalists and neovitalists is likely to continue with varied success on shifting battlefields. We can hardly be expected to settle the question this evening.

Let us, however, note three conclusions: Every form of matter comes from matter; every form of energy comes from energy; every living cell comes from a living cell.

The first two statements have already been shown to blend into one, so that matter may now be regarded as merely one form of energy. Nor need we doubt that life is also a form or manifestation of energy. What, then, is energy? Every schoolboy is ready with the answer, "Energy is the capacity for doing work." A mere translation! However, many schoolboys are capable of the more important step of actually measuring such work. Yet the definition reminds us of the gibe of Ruskin. "Why are the leaves of a tree green?" "Because they contain chlorophyll." "Then," he says, "you tell me that leaves are green because they contain green-leaf!" But truly, the situation is not as bad as it seems, inasmuch as man has now acquired so full a knowledge of what we may term the "habits of energy" that he can not only trace the interchanges of energy in nature, but he can also direct energy to his advantage and benefit. There is the enormous further achievement that energy is measurable by man and this is the first necessity for control. Hence there arise the multitudinous applications of mechanics and electricity which have invaded our lives in abundance and with such complexity, all depending upon known principles of physics. Indeed, we are rather intoxicated by these successes which leave the impression of far greater wisdom than perhaps we can justly claim, and we are apt to regard progress in mechanical and electrical contrivances as progress in civilization, which, of course, depends not only on material, but on intellectual, moral and spiritual values and qualifications.

ORIGIN OF LIFE

As to the origin of life, it remains, like the origin of matter, quite obscure. But the problem is not in the same category. To account for the origin of matter we have to regard it as arising from nothing; we have to consider energy proceeding from no energy, something quite outside our experience, and so unthinkable. It is not so when we consider the origin of life, where the material and the energy are both available. Hence there is speculation in the direction of highly complex molecules originating, step by step, from the simpler available molecules by the action of the ultra-violet rays of the sun. Some first fruits of chemical experiments in that direction have appeared. To be precise, sunlight has coaxed, so to speak, water and carbon dioxide to form formaldehyde. That step is truly a long way from the living cell. Rather vague terms are used to explain the further stages, such as surface tension and osmotic pressure, but my biological friends state that no "simple" cell is known to them. There is very great complexity in the simplest forms of life. Moreover, an eminent physiologist (Adrian) has stated:

> The nervous system is a mass of living cells which has the extraordinary property of appearing to influence, and to be influenced by, the mind. . . . It is a material system somehow responsible for such non-material things as emotions and thoughts. These are in a category outside the range of mechanical explanation, and for this reason the working of the nervous system will never be fully explainable in terms of physics and chemistry.

Again, Lord Balfour, writing as a philosopher, states, "No man can either perceive or imagine the mode in which physiological changes give birth to psychical experiences."

Most of us will concur with these verdicts, but we must remember that there is a more daring school who repudiate these limitations, due, they say, to the present imperfect state of our knowledge.

If the organic rose from the inorganic, then there is the first stage of the stupendous developments of life, both in number and in type, which surround us on this wonderful planet. Certainly a single fiat of creation has, in most thinking minds, given way to the more glorious conception of the perpetual creation which surrounds us. To-day is created anew from yesterday. One second gives birth to a fresh and different succeeding second, and yet between them an enduring linkage occurs. While it is not difficult to coin phrases to describe and summarize this remarkable development, and perhaps the term creative evolution is the most helpful, yet we must use it merely as a label or description, and avoid the common blunder of confusing a name with a cause.

Somehow in the human frame the front legs have become arms, and the front feet, hands, while one digit on each hand has become a thumb. The young child crawling on all fours as a little quadruped painfully and with repeated practice raises himself on his hind legs and learns to walk. Only the anatomists and physiologists are fully aware of the intricate coordinations which these efforts, conscious and unconscious, demand on the brain, nerve and muscle. Does the young child herein repeat a part of the story of the race, of its ancestry? Indeed, it has been stated that "every bone and every muscle of man's body have undergone profound structural alterations to fit him to his orthograd posture."

Certainly repeated struggles and strivings are necessary for the preservation and development of every form of life, while disuse leads towards annihilation; but these sage reflections, which may briefly summarize an observable process, leave all the most fundamental questions unanswered.

The highest development perceived or known in the universe is found in the intelligence and soul of man. Just as the properties of space have given rise to the rather vague term, ether, as a term indicative of properties and happenings, so such words as mind and soul are convenient summaries for unquestionable attributes.

It is somewhat strange to think that if the whole human species were submerged in Lake Ontario the water would rise but a few inches, and doubtless the universe as a whole would go forward but slightly affected, and dynamically and materially unimpaired. There was such a time, perhaps less than ten thousand million years ago, when there was no life on this earth; there will be such a time perhaps a hundred thousand million years hence when life on the earth will have passed away. Few will dispute the calculation of Harold Jeffreys that in a million million years all the waters of the ocean will have frozen to the very bottom and all the land be covered with ice and snow. Go, however, into one of our great libraries and you will find that the majority of books deal with man and his history and achievements. Why this importance attached to man? Do we flatter ourselves? Can we be just super-monkeys traveling on a speck of a planet going round a commonplace sun?

This pessimistic suggestion stands in sharp and dark contrast with the idea that this world is a training ground for immortal spirits. The view of Professor A. N. Whitehead may prevail that though the universe is physically descending, yet it is spiritually ascending.

PHYSICAL FIELDS

In order to further an attempt to approach a general view of the universe it is desirable to return for a while to the ideas of Faraday and to contemplate what he termed fields of force, or, as we might say, domains of energy. In a notable sentence he writes:

> The view now stated of the constitution of matter would seem to involve necessarily the conclusion that matter fills all space, or, at least, all space to which gravitation extends (including the sun and its system); for gravitation is a property of matter dependent on a certain force, and it is this force which constitutes the matter. In that view, matter is not merely mutually penetrable, but each atom extends, so to say, throughout the whole of the solar system, yet always retaining its own center of force.

It is probable that Einstein could modify this statement so as to cover his theory of gravitation where a geometrical field is caused or modified throughout space, so as to account for the motion of the heavenly bodies without the "forces" of which Newton conceived and about which Faraday was writing.

The word "field" has a wide use in the English language, such as hayfield, battlefield and so forth. In every case it denotes an area or region of events or happenings. Its introduction into physics has been fruitful. Near the earth, matter falls towards the earth in straight lines or curves and we can explore the laws or habits of material objects in this gravitational field. Newton extended this localized field from the earth outwards to the moon and throughout the

solar system. To-day the field is extended to include the motion of the double stars.

Around the earth there is also a magnetic field wherein a compass needle takes a definite direction. So also an electrically charged body is surrounded by an electrical field. At the present time we are immersed in an electromagnetic field, witness these rays of light perceived by our eyes, and the radio or wireless waves which now at all times penetrate even through our homes and very bodies. Attention should be directed to the important fact that there may be complete overlapping of fields. At one and the same place gravitational, electric and magnetic fields coexist. Hence the efforts of Einstein and of Eddington to get one, and only one, "field" which will give a full description of all gravitational and electromagnetic events.

Three things are essential for perception: the source or broadcasting station; the receiver, which must be duly tuned to the source, and the transfer of energy through space. Thus the atoms in the sun broadcast light to us, but we perceive with our eyes only those rays to which our eyes are tuned—that visible octave which is but a fraction of the great spectrum of total radiation.

The importance of correct tuning is now well understood in radio reception, as in all electromagnetic fields, but it is desirable to realize its wider applications. Conversation in the ordinary sense is not possible either by the dumb or to the deaf. The one lacks the transmitting power of speech, the other the receptive power of hearing. Now there are also mental or intellectual fields where a thinker has ideas which he wishes to convey by speech or writing to other intelligences who are willing to understand and receive them. Who can overemphasize the importance not only of intellectual capacity, but also of sympathetic tuning in all mental fields, wherein again form, structure and style are nearly as important as subject or substance?

No less is this true in all forms of art. It is the glory of the artist to create an artistic field. Appreciation of this field by the observer or recipients again depends on the receptivity both as regards capacity, and quality or value. In mental and artistic fields all the precision of mathematical physics is lacking. Measurable quantities are entirely absent. Judgment, good sense and experience are the sole guides of value. But there is beyond all this, indefinable and precious, that inspiration and genius which persuade us that there is something more and something greater than we can include and define in purely physical fields. Yet if we are going to chop up the universe into wholly independent regions, we at once lose that simplicity and generality which it is our hope and ambition to achieve. It is believed that when conflict arises between two domains of thought, for example, religion and science, the reason for such conflict resides in our limited knowledge and intelligence. When conflicts occur in nature, readjustment necessarily and inevitably corrects them.

Greatest of all are those fields where the spirit of man is tuned to the spirit of the universe, so that man is, as it were, a god, or is in complete communion with God.

Are these ideas idle dreams or fantastic visions? No! We can claim as much reality for spiritual fields as for mental, artistic or physical fields. "By their fruits ye shall know them!" Here indeed may be the secret of secrets! The direct evidence of spiritual fields is found in the attributes and experience of those who, finding themselves *en rapport* with the divine light, bear testimony, by their lives, by their actions, by their thoughts, by their influence, that the inner light guided by reason is no mere illusion or dream.

I choose two illustrations. Mr. Baldwin, politician and statesman, lately premier of England, states:

> For myself I say that if I did not feel that our work and the work of all others who hold the same faith and ideals, whether in politics or civic work, was done in the faith and the hope that some day, maybe a million years hence, the kingdom of God would spread over the whole world, then I would have no hope, I could do no more work and I would give my office over this morning to any one who would take it.

These words of Mr. Baldwin's evoke admiration and awake an echo in our souls. And yet—there is a stage even more noble, where those who feel that they are playing a losing game or know that they are fighting a hopeless battle persevere in their undaunted quest for the truth, which includes all that is good and beautiful, persevere in scorn of consequence.

Yet one more witness by a woman, who, in face of disappointments, ill health and approaching death, wrote that fine swan-song, "No coward soul am I!" concluding with her life's vision:

> With wide embracing love
> Thy Spirit animates eternal years
> Pervades and broods above
> Changes, sustains, dissolves, creates and rears
> Though earth and man were gone
> And suns and universes ceased to be
> And thou wert left alone
> Every existence would exist in Thee.
>
> —*The last poem of Emily Brontë*