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THE EVOLUTION OF COSMOLOGIES

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1. The Riddle of the Universe. Man is by nature a creature who is curious. He must have theories and explanations. He wants to understand why there is a universe; and he wants to know what kind of a universe it is that he inhabits. Primitive man has his myths about the origins of things, and the modern scientists have their latest speculations about the universe. And of the making of cosmological hypotheses there is no end.

For countless ages the "riddle of the universe" has baffled the mind of man. From the dramatic Old Testament story of creation to the most recent speculations of Einstein, George Gamow, and Fred Hoyle, there stretches a long and fascinating record of attempts at a solution to this ageless problem. This story is absorbing for its own sake, as revealing the human mind working at its superb best; but it is also interesting to the scientist as a story which he must know in order to build better models of the universe. Let us therefore review the evolution of cosmologies, the historical backdrop against which the newer theories stand out in sharp relief.

The story of cosmology begins with Pythagoras, about the year 550 B. C. Pythagoras and his followers established a sect or brotherhood at Croton (Italy), where they studied mathematics, astronomy, and music, and advanced ingenious cosmological ideas about "magic numbers," the music of the spheres, and the like. Here, for the first time, apparently, the idea is developed that the sphere is the perfect figure, and that the earth and the heavenly bodies are spheres.

A Pythagorean student named Philolaus (of Tarentum, about 450 B.C.) proposed that the earth is similar to the other planets in its movements and that they all revolve around a central fire. This student published a book expounding the Pythagorean doctrines. His exposition had a considerable influence on the formation of Plato's theories (as set forth in the *Timaeus*) where the five regular Platonic solids are discussed. (These solids, which Euclid deals with in his *Elements*, are the *tetrahedron*, the *cube*, the *octahedron*, the *icosahedron*, and the *dodecahedron*.)

The Pythagorean idea of a central sun had a great influence on Copernicus—who was thus led to the "heliocentric" cosmology—while the idea of the Platonic solids gripped the mind of Euclid and swayed Kepler's mind into rhythm with the "music of the spheres" of Pythagorean mysticism.

The first inventors of a full-blown cosmology were the early Greek atomists.

The originator of atomism (materialism) was Leucippus, who lived about 475 B. C. But the atomic theory of matter as it has come down to us is due mainly to the work of Democritus, a student of Leucippus who overshadows his teacher. According to the atomists, all things are made up of atoms and the empty space or "void" between the atoms. The atoms are eternal, indivisible, small, incompressible (the word "atom" means "indivisible"). The atoms differ from each other in form, weight, and size, but otherwise they are homogeneous.

Just as the atoms are eternal and uncaused, so also is motion eternal, originating as it does in preceding motions. Thus we have here the beginnings of the later doctrines of the conservation of matter and the conservation of energy. Since all things are constituted of changeless atoms, the history of the universe is simply the story of the rearrangements of atoms, the tangling and untangling of mass particles in space.

The atomic theory explained the evolution of the universe in the following fashion. In the beginning (i.e., before the world in its latest tangled-up state had appeared) atoms were falling through empty space (void) with no guiding force or purpose. The heavier atoms fell faster than the lighter ones, thus forcing the lighter ones upward. This incessant motion produced a vortex and out of this vortex the universe was born—somewhat as the later "nebular hypothesis" of Kant and Laplace supposed. The atomists explained the "four elements" of the other philosopher-scientists (earth, water, air, and fire) as arising out of the intermingling of atoms. Of course in such an endless procession of universes—our world is only one of an endless number of worlds that arise and pass away—history repeats itself over and over again. Here, too, we have the essentials of all materialistic philosophies, ancient or modern, that there is no pattern of meaning in cosmic evolution, and the universe is a result of an accident.

The next great figure in the evolution of cosmologies is Aristotle, the "master of them that know," as the medievals termed him. In Aristotle the basis of physics and astronomy is the world of common sense, the world as we experience it with little of mathematical abstraction added. In such a world objects are hot or cold, wet or dry, they rise or fall, and so on. Aristotle rejects the atomistic-mechanical view of Democritus (*atoms* and *void*) and embraces the notion that qualitative differences are objective and real and not due to subjective (inter-organic) rearrangements of particles. In a similar manner, Aristotle rejects the abstract and mathematically expressed concepts of the Pythagoreans in favor of the qualitatively sensed elements as they unite and pass into each other—a doctrine which provides the basis for later speculations of the alchemists concerning the "transmutation of the elements." It is important to note, however, that while Aristotle has preserved the earlier "elements" of his predecessors—earth, water, air, and fire—he has added a fifth element, ether, which was destined to play an important part in later cosmological theories.

In Aristotle's physics there are three kinds of motion: rectilinear and circular, plus the motions which can be compounded from these first two. Rectilinear motion is characteristic of the four elements; this type of motion is not continuous as circular motion is; it has a beginning and an end, and it is not everlasting.

Circular motion is the natural movement of the fifth element, ether, of which the heavenly bodies are composed. This leads to the doctrine that the planets, sun, and stars move around the earth in circles, the perfect type of motion. The earth, the center of the universe, is a sphere,—that is the teaching of the "geocentric" cosmology. Around it, in concentric circles, is a nest of etheric spheres, one inside the other like Chinese boxes, and the whole system is moved by the outermost and all-embracing sphere.

Roughly the universe is divided into two parts, the earthly and the heavenly, below and above the moon. *Terrestrial* physics, dealing with the motions of the four elements, has nothing in common with *celestial* physics. Earth and water tend toward the center of the terrestrial sphere (earth), while air and fire tend toward the circumference of the sphere. Thus we get the distinctions of up and down, and light and heavy. These tendencies of bodies to find their natural places are interfered with by the seasons, climate, and processes of generation and decay, which keep the elements and their motions mixed up.

As we go outward from the earth at the center, the universe becomes purer and purer, until it passes into ether. That is, to repeat, around the earth in successive layers are water, air, and fire; then come the celestial spheres carrying the planets, the sun and the moon, and finally the fixed stars. God resides in the outermost sphere of the fixed stars and causes it to move, and by the motion of the Prime Mover (*Primum Mobile*) the other spheres are caused to move in their perfect spherical paths. Thus God is the Unmoved Mover, the Uncaused Cause, of everything in the universe. Aristotle's universe is eternal in time, though in space it is finite, being in fact spherical in shape.

2. Medieval Cosmologies. Aristotle's geocentric system was given a more elaborate exposition by Ptolemy of Alexandria in the second century A. D. The combination of the two earth-centered theories is usually referred to as the Ptolemaic cosmology—a synthesis that persisted unchallenged for fifteen hundred years. In the thirteenth century St. Thomas Aquinas reaffirms the Aristotelian-Ptolemaic cosmology substantially as it had been passed on to the medievals, except that Aristotle's Unmoved Mover, in suitable modified form, becomes the Christian God, the Creator who made the universe at a definite time in the past. Thus one important change is introduced into Aristotle's cosmology: the geocentric universe now becomes finite in time as well as in space, whereas for Aristotle it was eternal in time.

Of course in this respect—that is, in taking over the physics and the astronomy of Aristotle—St. Thomas was typical of the age in which he lived. All the scholastic thinkers accepted the contrast between the more perfect matter of the heavenly spheres with the matter of the terrestrial elements. The celestial (heavenly) bodies partook of the superior circular motion, whereas the terrestrial elements (the four elements of the ancient Greeks), being of an inferior nature, followed common straight lines.

As one would expect, Aquinas holds firmly to the doctrine of the Unmoved Mover who makes the stars and planets revolve in circular orbits through sheer love of perfection. It is important to note, however, that while Aquinas accepts

the Aristotelian geocentric astronomy as amplified by Ptolemy and others, he does recognize that it is a provisional hypothesis which might someday be supplanted by another explanation of the perceived motions of the heavenly bodies.

3. Early Modern Cosmologies. The first serious challenge to the geocentric cosmology was provided by Nicholas Copernicus (1473–1543), a Polish astronomer who became Professor of mathematics in Rome in the year 1501.

Following the idea first advanced by Pythagoras and Aristarchus, Copernicus proposed the view that the earth and the other planets revolve around the sun as the center of the solar system. The book in which this new system is set forth has the Latin title *De revolutionibus orbium Coelestium*, and it was published in Nuremberg in 1543. It is said that the first copy of this book was put into the trembling hands of Copernicus as he lay on his death bed.

While the Copernican system was rejected by the authorities of the time, the initial effects of what later became the "Copernican revolution" were neither widespread nor disturbing. It was not until later, when Giordano Bruno and Galileo boldly announced the consequences of the new theory, that the real conflict arose.

Copernicus did not entirely free himself from the old habits of thought. He retained the following ideas from the earlier geocentric system: (1) there is a center of the universe—the sun takes the place the earth formerly occupied; (2) the circle is the most perfect figure, and all heavenly bodies revolve around the sun as the center of the universe; and (3) the universe is spherical and finite in size—as Aristotle taught—terminating in the sphere of the fixed stars.

The first serious clash between the older theology and the new cosmology comes with the teachings of Giordano Bruno (1548–1600), a member of the Dominican order, a restless wanderer who seemed predestined to tragedy. The first philosopher to accept the heliocentric theory of Copernicus, Bruno rejected the finite universe of Aristotle and taught the doctrine of an infinity of universes. Bruno was much impressed by the immensity of the universe as revealed by the new astronomy and held that the stars are planetary systems like our own, so that the earth has no privileged position in the universe.

Bruno in forthright manner proclaimed this new universe, without center or circumference, in which all places and all motions are relative—a universe endless in space and time whose soul abides uniformly in every part. Bruno was not an atheist. God is not the Prime Mover, nor is He the Creator of the universe; like the Stoic pantheists, Bruno regards Him as the Soul of the Universe. This was regarded as heresy, and so Bruno came to his untimely end.

Galileo Galilei (1564–1642), the Italian astronomer and mathematician, discovered many remarkable things through the numerous telescopes he constructed. He resolved the Milky Way into a host of stars; he saw the rings of Saturn, and mountains on the moon. His studies of the law of falling bodies and his investigations into the laws of the pendulum mark the beginning of modern physics.

Galileo adopted the Copernican system and taught it; but as a maker of an original cosmology he is not distinguished. However, like Bruno, he did understand the philosophical consequences of the new developments. Like Bruno, he

taught that the universe is boundless, without an inner and an outer part, a universe with no beginning and no end in time and space.

It remained for one of Galileo's contemporaries, Johannes Kepler (1571–1630), to take the next important steps. A convert to the Copernican heliocentric theory from the very start, Kepler abandoned the idea that the planets revolve in circles (Aristotle, Ptolemy, and even Copernicus advocated this) and formulated instead his famous laws of planetary motion based on the idea that planets revolve in ellipses around the sun. His idea of the harmony of the universe is the Pythagorean-Platonic notion, and he tried unceasingly to fit the five intervals between the then six known planets into the scheme of the five regular solids of Plato and Euclid.

What is especially interesting in Kepler's speculations is his guess that the motions of the planets of the solar system are related to the sun's rotation and regulated by electromagnetic laws. Apparently both Kepler and Descartes were influenced in their thinking by the work of their English contemporary, Dr. William Gilbert, and regarded electricity and magnetism as forms of vortical motions. When one recalls that Gilbert in turn had been influenced by Bruno (who had visited England in his wanderings), one gets some notion of how ideas spread out like ripples in a pond.

Sir Isaac Newton (1642–1727), England's most distinguished scientist, was born in the year of Galileo's death. He was so gifted that by the time he was twenty-three years of age he had already formulated the binomial theorem, had discovered the fundamentals of the differential and integral calculus, had analyzed light into its separate components, and (in his own words) "in the same year (1665) I began to think of gravity extending to the orb of the moon. . . ." The latter research, of course, was to culminate in Newton's universal law of gravitation.

While Newton did not invent a novel cosmology, his physical theory is so basic for later cosmologies that we cannot disregard it. In this matter what many persons, even scientists, fail to realize is the extent to which Newton's physical theories were the explication of an underlying metaphysical theory. Here in briefest form is the story.

Newton took over the theological-metaphysical ideas which permeated the intellectual atmosphere of Cambridge University, where Newton studied and taught. Men like Henry Moore, a Platonist who influenced Newton's views on these matters, were declaring that space and time were "nothing but the omnipresence and eternal duration of God," thus deifying the framework of nature as the matrix of the divine presence. Professor Hermann Weyl, in his volume on *The Open World* (1932, pp. 18–19), regards Newton's space—the *sensorium Dei* or sensorium of God—as a later interpretation of the Stoic ether as a deified potency of nature. However that may be, it is entirely reasonable that Newton in his "General Scholium" to the *Principia* should exclaim: "By existing always and everywhere God constitutes duration and space." Again, in the *Opticks*, we find Newton declaring that "God moves bodies within his boundless uniform sensorium."

This notion that absolute time and space are the *sensorium Dei* made it possible in the Newtonian theory to define an instant unambiguously for the entire universe (i.e., independently of the coördinate system). Motion, therefore, is also absolute because space (the sensorium of God) gives a fixed frame of reference. Thus the "inertia" of bodies can be overcome by "forces," and both are real. All this makes it possible for Newtonian (classical) physics to determine whether two events (on two different planets, for example) are occurring simultaneously. The Newtonian conception of action is based on the idea that force can be transmitted instantaneously through space, or with an "infinite velocity." As we know, the later-discovered negative results of the Michelson-Morely experiment suggested the impossibility of measuring motion relative to the ether (the space-sensorium of God in Newton's system) and the consequent theory of the relativity of motion therefore eliminates motion and force as absolute (objective) realities.

Newton's views on the absoluteness of space and time are clearly set forth in the famous passages in Book I of the *Principia*. But it is not clear whether in Newton's system the universe is finite or infinite in space, though with respect to time Newton left us in no doubt: he definitely is committed to the view that the universe began at some finite time in the past. Proof that Newton believed in a universe that had a beginning is provided by the statement in his book on *Opticks* where he states: "All these things being considered, it seems probable to me that God in the Beginning formed matter in solid, massy, hard, impenetrable, movable Particles. . . ." Thus spake Newton.

In all these speculations, ancient, medieval, and early modern, the reader may notice the persistence of a certain habit of thought, namely, the fixed idea that the atoms of physics do not exert fields of influence. Matter is composed of particles that are eternal, or, if created, are brought into being at some time in the past and then put into empty space ("void"); but in either case space is regarded as an antecedent, empty vessel or container into which matter can be put. This is the traditional theory of materialism that was bequeathed to classical physics. From Democritus to Galileo to Newton we find little change: they all suppose that the corpuscles of physics exert no fields of force, but are passive particles acted upon by forces from without. Only Newton had some doubts about this fundamental tenet of particle-physics.

It is this fatal defect of "elementalism" that invalidates all earlier cosmologies. The newer theories of matter make possible novel theories of the universe, but before glancing at the recent cosmologies let us summarize the lessons we have learned from the historical survey of the subject.

4. Shortcomings of Traditional Cosmologies. 1. All cosmologies since the time of the ancient Greeks are at least partially false, because they are based on highly misleading ideas about space, time, and matter.

2. The conception of corpuscles as self-existent and independent atoms is the fundamental fallacy of ancient materialism and later classical physics.

3. Space and time are not antecedent vessels, empty containers, into which matter may be put. These three realities of the physical world constitute an

inseparable unity—the space-time-matter trinity. Space and time are not absolute and independent realities, as Newton thought; they are correlative and mutually imply each other, as Minkowski pointed out. This correlativity of space and time was first recognized by Fitzgerald in his well-known "contraction" hypothesis.

4. The relations between the "field" and "matter" take on a new significance in the contemporary electrical theory of matter: in pre-relativity theory matter cannot exist without space; for Einstein, space cannot exist without matter. Moreover, the field which permeates space now has a higher degree of reality than the "particles," which somehow appear as boundary-singularities or energy-knots in the field.

On the basis of these new insights, modern cosmologists are creating new models of the universe, and it is our purpose to glance at several of the better known conceptions.

5. Expanding Universe Cosmologies. The most striking advance made possible by the new conceptions of the relations of space, time, and matter is revealed in the present popular expanding universe formulations. We have it on the authority of A. S. Eddington that the first suggestion of an "expanding universe" is contained in a paper published in 1917 by Professor W. de Sitter. This has formed the start of a fertile line of thought.

The first empirical evidence for such an expansion was provided by Dr. E. P. Hubble, and later by M. L. Humanson, both at Mount Wilson Observatory. The supposed expansion is an inference from the observed "red shift" in the spectral lines from the spiral nebulae and is supposedly indicative of their recession into the depths of space. This means, if the interpretation is correct, that the radius of the universe is changing with time, and the velocity of recession or expansion is proportional to the distance—that is, the further away the system is the faster it is rushing off into space.

It soon became clear that this "cosmical repulsion" should have been incorporated as an essential part of relativity theory, and indeed it was so accepted in Hermann Weyl's interpretation of relativity theory. Einstein's original solution—that the radius of space of the finite but unlimited universe remains the same—did not agree with the flight of the extra-galactic nebulae, and so Einstein had to extend his theory in the direction of the expanding universe conception. Today the *cosmical constant* termed "lambda" designates this repulsive force in the universe, and it is now accepted as an integral part of most cosmological theorizing.

The first deliberate exploitation of the possibilities that are inherent in the conception of an expanding universe was initiated in 1922 by A. Friedmann. The idea, once it was started on its career, expanded like the universe it depicts. The next important figure in this intellectual advance is a Belgian priest, Abbé Georges Lemaître, who proposed the view that the universe began with the radioactive disintegration of a single giant atom which then expanded into our present cosmos.

According to Lemaître, the evolution of the world is comparable to a display of fireworks. The Lemaître universe starts with a "primeval atom," highly

condensed and almost equal to the present mass of the universe, which exploded like an immense atom bomb into the space of the expanding universe. The radius of space began at zero, and when the "sun-atom" exploded this also marked the beginning of time.

In recent years Lemaître has done little to perfect this theory, and it has remained for others—like Professor George Gamow—to work out the finer details of this "special creation" theory. Let us therefore glance at Gamow's conception.

6. Gamow's Story of Creation. According to Dr. George Gamow, theoretical physicist at George Washington University, the universe had its beginning only a few billion years ago. Various lines of evidence converge toward the conclusion that the universe as we now know it is a result of an evolutionary process that started about three billion years ago. This cosmology gives a timetable for the formation of the ninety-two elements, beginning with hydrogen and ending with uranium.

When the curtain first rose on this drama we find the universe beginning its expansion. At this time there was a mixture of neutrons, protons, and electrons—Gamow uses the ancient Greek word *ylem* to designate this first substance—and the mixture had a temperature of several billion degrees, much too hot to form elements. But with the expansion, and as the temperature dropped, combination of protons and neutrons into the nuclei of elements took place.

First in the order of formation were the deuterons, nuclei of heavy hydrogen, after which came tritium and helium and then the heavier atoms. By the end of the first hour of creation all the chemical elements were formed in their present relative proportions, following which, in the subsequent expansion of the universe, these elements have been distributed throughout the universe. In the course of the successive acts of this cosmic drama the mixture of matter and radiation has cooled; the densities of matter and radiation are equalized; and gaseous galaxies have formed into gravitationally stable systems; and finally stars evolve in the galaxies and acquire their present shapes. The rotation of the galaxies produces solar systems such as ours, and by this process our own system, including the earth, comes into being. After the lapse of a billion years, the earth cools down to its present temperature and life as we know it becomes possible.

In this remarkable story of creation, the matter which originally had a density of one hundred trillion grams per cubic centimeter has been spread over space and is still stretching out as galactic systems recede into further space. Such, at any rate, is Gamow's breathless story of Creation.

7. Another Version: Creation Still Taking Place. But even more startling conceptions are available. Among the better known of these new cosmologies is the one now being presented in England by Fred Hoyle and his colleagues at Cambridge University.

Hoyle reinterprets the theory of the expanding universe in such a manner that the receding galaxies that lie in the remotest parts of the universe attain a velocity that exceeds the speed of light (this is not supposed to contradict Einstein's theorem). In the mean time, as this matter disappears over the edge of

the universe, new matter is being created within our observable part of the universe, and so we have a universe that is infinite in both time and space. Unfortunately, Hoyle is unable to give any explanation for the creation of matter. In this respect his theory is no more satisfactory than Gamow's, which, as we have noted, begins that act of creation with a giant explosion. In both cases we are left with something of a "miracle"—how does something come from nothing?

It matters little whether one believed that the universe was created in the year 400 B. C. or three billion years ago: in either case one may well wonder—without being irreverent—what God was doing before He decided to create the universe? In a word, there is a genuine difficulty with any theory that starts the universe off under circumstances radically different from those that prevail

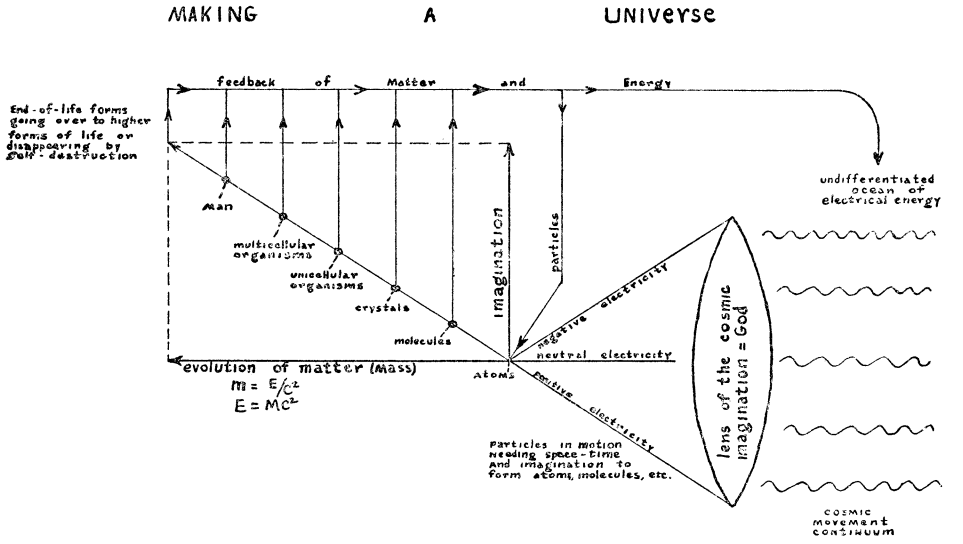

FIG. 1. In pantheism "God" is man's name for the Guiding Field or Cosmic Imagination by means of which undifferentiated energy is focused in nodal points in space-time, subsequently to evolve under the influence of guiding fields on higher levels.

before or after the creative process. Hoyle's escape from this dilemma merely locates the difficulty in another place: the continual creation of matter still leaves us with an inexplicable phenomenon. All things considered, the one philosophically sound conception is that proposed by Giordano Bruno—a universe that is infinite both in time and space and containing an endless number of worlds. But this cosmology must be redesigned to accommodate the modern concepts in physics and astronomy, in the light of formulations that were not available to Bruno, Galileo, and Newton. This new conception might appropriately be called the *Cyclic-Creative Universe.*

8. The Cyclic-Creative Universe. In the belief that it is possible to develop a theory free from the difficulties of a universe limited in time, the present writer and a Dutch engineer named B. G. H. Vanderjagt have together worked out the conception of the cosmos as it is pictured in the accompanying diagram. This

conception gives us a universe eternal in time and infinite in space, in which "creation" is still taking place—but this creation does not consist in making "something out of nothing." As here conceived, creation is a process in which, as the field-energy of an ocean of electrical density is converted into corpuscles (the "energy-knots" or "boundary-singularities" that are known as electrons, protons, neutrons, and the rest), an equivalent amount of matter is "destroyed" by dissolving into the ocean of cosmic energy. Thus nature preserves a balance or constant proportion between the amount of "matter" present in the *manifest universe* of particles, which are actually or potentially perceptible, and the amount of field energy of the *unmanifest universe* which lies outside all special space and time coördinate systems.

It is not possible to explain this theory in all its details, but as it now stands, here are the main features of what, for want of a better term, we describe as the *cyclic-creative universe.*

1. The universe can no longer be conceived as the world-machine of Newtonian-Laplacian particle-physics. The cosmos is here pictured as the expression of a *Guilding Field* (or *Cosmic Lens*), impersonal and non-anthropomorphic. This conception of a *Cosmic Image-forming Influence* which guides the processes of individuation and integration promises to weld into one world-view the Pantheism of the Stoics, Bruno, Spinoza, and certain features of Einstein's unified field theory.

2. Behind the phenomena of nature which man investigates by way of his senses lies an *Undifferentiated Ocean of Electrical Energy*, eternal in time, uncreated, and outside all spatial coördinate systems. "Matter" emerges from this cosmic energy continuum through a process of focalization *via* the "Cosmic Lens," whereby nodal points are individuated into the space-time matrix of our sense-perceptible world. *Imagination is a name for that organizational reality in nature in virtue of which parts are made and put together in their right times and places to form products.*

3. The appearance and disappearance of the ultimate discrete particles is not due to chance, but conforms to a law which reflects a balance between the world in space-time and the world outside space-time. *For Pantheism, God is not the Creator of Cosmic energy—He is the form-producing influence that operates within the matter-energy cycle to control evolutionary integrations.*

4. *Einstein's principle of the equivalence of matter and energy is a recognition of nature's equilibrium between the manifest world in space and time of the perceptible world and the unmanifest world of the field-plenum from out of which matter emerges and into which it returns.* The ultimate particles of electricity constitute points of entry into the three-dimensional physical universe, and since matter and the field are cosmic complementaries and mutually sustaining, the reverse process of the annihilation of particles, dissolving into the field-plenum which is outside the space-time matrix, must also occur.

5. Thus we live in a cyclical, but non-repeating, universe within which "creation" on all levels of matter, life, and mind is taking place under the influence of guiding fields. Cosmic energy, if it could exist alone, would not be intelligent;

only when it is endowed with imagination does it become intelligent. *Accordingly, energy plus imagination produces creative evolution.*

6. The physical universe, therefore, is the actualized body of the Supreme Imagination, being composed of the cosmic forms that have been crystallized as visions of reality as these have been structuralized in the ever-evolving patterns which are in fact the story of creation, the history of the universe. *Cosmic evolution, in a word, is a never-ending and creative advance as revealed by the manifest universe.*

7. Now the obligation of man is to take over the uncompleted drama of evolution and carry forward the story of creation to its next climactic scene. *The god-in-man is nothing other than cosmic energy become aware of itself as imaginative foresight.* Cosmic energy is a non-moral force in nature, until it reaches up into human consciousness as integrated personality. Human freedom is the vision of future possibilities, the imaginative construction of forms to be created on the basis of past achievements. Human freedom is conditioned by biological heredity and the cultural forms of the social matrix.

8. *In order that humanity may survive and continue this "creative advance of nature," man requires a scientific basis for morals.* He needs to realize that physical laws and moral principles are interwoven on the human level, so that the regulative principles of a universal civilization are not arbitrary conventions, but do in fact provide the firm foundation for the good society. The realization of creative imagination is the form-producing force behind physical, biological, and human social evolution.

9. *Both communism and western science overlooked something, and that is the Supreme Imagination which gives form to all the products of nature, and without the Supreme Imagination or Cosmic Guiding Field the whole show is meaningless.* Why man is on this tiny speck of the universe we call the earth will be understood only as we increasingly comprehend the universal scheme of things. Man's highest mission is to understand and enjoy the productions of the Supreme Imagination as these are revealed in nature.

10. *To present a real alternative to defeatism, despair, and disintegration, a new world philosophy must be evolved by man, a modern cosmology must be formulated, and this might well be based upon Pantheism.* This Pantheism would appear as a scientific world-view providing a mediating ground between the atheism of Russian Marxism (Communism) and the theistic supernaturalism of the Hebrew-Christian religious tradition of the democratic countries that are combatting Communism.

The major religions of the world (Hinduism, Judaism, Christianity, Mohammedanism, Communism, and the rest) started out as regional religions with characteristics peculiar to the times and places of their origins. All local religions with their regional gods are therefore stations along the way as man climbs upward toward the realization of his own divinity; they are manifestations of man's ceaseless effort to envisage that Supreme Imagination in whom we live and move and have our being. These traditional religions and their accompanying cosmologies have erred in laying claim to final truth. In Pantheism there is a sense

of awe and reverence in the presence of a sublime universe, but there is no finalism of creeds or cosmology.

9. Some Unsolved Problems. The foregoing conception has a kind of symmetry about it that is philosophically satisfying. According to current ideas, the energy of matter comes from an unknown source and proceeds outward into space toward an equally unknown destiny. But if the "source" and the "sink" can be tied together in the manner we have indicated, we may have an approach to an explanation of where the atoms get their energy and why the universe hasn't run down long ago. This energy-matter cycle reminds one of the ancient image of eternity: a serpent swallowing its own tail, except that within any given galaxy the inner history need not repeat itself. Thus we are freed from the depressing doctrine of "eternal recurrence"—which may have contributed to the onset of insanity in the philosopher Nietzsche.

In looking about for the scientific antecedents of this theory, one thinks first of all of Einstein's static (non-expanding) universe, with the proviso that we abandon the notion of its "finite but unlimited" size and, as indicated, return to the infinite universe of Bruno. But in more precise fashion, the one theory which appears as an "anticipation" of the present view was outlined roughly by Professor W. D. MacMillan. Professor MacMillan once pointed out that radiation may not disappear into the blackness of the night skies, but sooner or later may be reborn in the energy of the newly incarnated atoms, so that in turn the stars (like our sun) have the energy available which can be derived from the consumption of their own masses.

Of course there are difficulties confronting this theory. For one thing, the precise mechanism for the reciprocal convertibility of matter and energy still remains to be worked out. It may be that the recent investigations concerning the role of "mesons" in physical transactions will be helpful here, (the word "meson" is a shorter name for "mesotron," which is a middle-weight particle). In the Gamow and Hoyle universes the mesons have no significant part to play. But we may be on the way to a more adequate understanding if we bring mesons into our theories as nature has brought them into her energy-matter cycle. Let us say a word about this.

One important problem for the physicist today is posed by the question, what holds the nucleus of the atom together? The answer when it is finally known, will tell us about the "binding energy" in the nucleus which holds the protons and neutrons together. This energy is far more powerful than any other force in nature that we know about. Part of the answer to the question of the source of this energy is believed to be hidden in the rôle of meson, because these mesons are connected somehow with this binding energy. These mesons are short-lived, coming into existence for only a ten-thousandth of a second. These particles are continually being born, only to die and be born again, but as they explode into bursts of energy forces are brought into play that are thousands of times more potent than those which come from disintegration atoms like uranium. Dr. J. Robert Oppenheimer has suggested that these unceasing "cosmic pulse beats" are somehow a manifestation of the energy that is needed to hold the parts of

the universe together in one body. Surely, therefore, when the full story is known, it may well be that mesons will prove to be a bridge between particle-physics and field-energy, a kind of "hole" in the "veil of reality" which separates the manifest world from the unmanifest world.

A second problem that the present theory must face is that it must give some account of the present distribution of the elements throughout the universe. One great merit of Gamow's theory is that he does have an explanation of the wide distribution and relative proportions of the lighter and heavier elements. From the fact that the proportions of the elements are about the same in the earth's crust, in the sun and other stars, and in meteors, Professor Gamow concludes that they had a common origin at about the same time—three billion years ago when the curtain on the stage first arose. According to this theory, if the process of the formation of the elements (atoms) had taken either a longer or a shorter time than the one-half hour that Gamow estimates, the proportions of the light and heavy elements would be different from what they are actually found to be.

But we must not assume that there is only one way to explain the proportions and distribution of the elements. Other hypotheses may be invented to account for the facts. For example, on our theory the same mechanism that maintains the matter-energy balance may stabilize the relative proportions of the elements, all widely dispersed throughout space all the time. Nevertheless, it is admitted that this still remains to be worked out in terms of the "guiding field" concept. When this has been perfected, we surmise that the meson-field, which provides the adhesive forces that keep the nuclei together despite the tremendous repulsive forces inside the atoms, and which possibly bridges particle-physics and field-physics, will form an integral part of the new conception.

The last major difficulty has to do with the "red shift" that provides the main evidence for the "expanding universe." Here, again, we speculate that an alternative explanation is possible. Two alternatives come to mind: (a) the red shift might be due to the presence of interstellar matter which changes the frequency of the light rays; or (b) it is possible that the universe is not expanding *outward* into space with the passage of time, but is dissolving *downward* into the unmanifest world.

Obviously it will be difficult to make this second alternative plausible—though a principle of symmetry does support it. If energy is precipitated into space-time as "particles," is it not possible that "matter" in turn dissolves back into the universal undifferentiated ocean, and as evidence of this dissolution slows down its vibrations as it disappears through the veil into the unmanifest universe?

In any case, the idea of an "expanding" universe no longer appears as the only explanation of the "red shift." As a matter of fact, our rejection of the expanding universe in favor of a cyclic-creative universe finds some support in suggestions made by Dr. Edwin Hubble, whose experimental investigations are at the basis of the whole conjecture. In an important article on this subject, Dr. Hubble[1] points out that "Red shifts represent Doppler effects, physical recession of the

[1] Cf. "The Problem of the Expanding Universe," by Edwin Hubble, American Scientist, Vol. 30, 1942, 99–115.

nebulae, *or the action of some hitherto unrecognized principle in nature.*" The reader will notice that the phrase I have italicized suggests the possibility of a new principle. A careful reading of Hubble's article reveals that Hubble is not at all enthusiastic about the expansion theory. He concludes his paper with these words: "A choice is presented, as once before in the days of Copernicus, between a strangely small, finite universe and a sensible infinite universe plus a new principle of nature." May we not propose our cyclic-creative universe as a substitute for the "strangely small" universe of Lemaître and his successors, solving the riddle by our "new principle" of a reciprocal conversion of matter and energy as a balance between the manifest and unmanifest universes, wherein new dimensions (with orthogonal time-axes) in an emergent hierarchy are pyramided on to the foundational four-dimensional matrix, as indicated in Diagram II? It is our hope that the argument for such a conception will be strengthened in future articles on the subject.

10. New Developments in Cosmology. As widely reported in the news of Thanksgiving day (see, for example, the *Washington Post*, Nov. 23, 1951), Pope Pius XII informed the scientists of eight nations meeting under the auspices of the Papal Academy of Science that recent scientific developments not only give evidence of the existence of God but also indicate that God created the universe approximately five billion years ago. This statement from His Holiness places the Vatican's approval on the "expanding universe" interpretation of the "red shift"; thus the Friedmann-Lemaître-Einstein-Gamow explanation of the Mount Wilson experimental findings is used to confirm the special creation theory of *Genesis*, with suitable modification of the time-scale since the "mighty beginning" of the cosmic processes.

It will be clear to the reader that this reconciliation of science and religion is not the one advocated in the present article. Our variety of Pantheism commits us to a "modernized" version of Giordano Bruno's conception of a universe infinite in space and eternal in time, with no "beginning" and no "end" of either. Propagating this theory caused Bruno some difficulties, and it is to be hoped that history does not repeat itself.

Our own view is that the "evidences" for the expanding universe are not convincing. The objections are: (1) the hypothesis that the beginning of cosmic time represents a situation altogether different from its "present" condition creates insuperable difficulties (a miracle, in fact); (2) it involves the notion of an explosion of a very compressed "primordial atom" containing the entire mass of the universe, but leaves this "atom" unexplained; and (3) the seemingly progressive degradation of energy into quanta of lower energy-value (so that the universe will eventually grow old and run down, as Pope Pius is quoted as declaring) is based on the second law of thermodynamics, and this principle has been shown experimentally to hold only for isolated systems, and—if the present conception of the reciprocal conversion of matter and energy is correct—cannot be shown to hold for the universe as a whole, especially when it is spatially infinite and temporally eternal.

To be sure, there are difficulties in the idea of an infinite universe. But these

difficulties cannot be used by theologians to discredit Bruno's conception, for the theologians, in thinking of God in terms of infinite attributes, are employing the same concepts but applied to a different object of thought. Difficult though the concept of the infinite may be (we think here of Brouwer's criticism of the completed infinite), the revised form of Bruno's cosmology as here presented receives a measure of support from E. Finlay-Freundlich's monograph of *Cosmology* (International Encyclopedia of Unified Science, University of Chicago Press, 1951), which was not available when the foregoing article was written. Here Professor Finlay-Freundlich refers (p. 2) to "Lambert's idea of a hierarchic structure of the universe" (no reference given). This turns out to be the theory that matter is so distributed in space that stars combine to form galaxies; galaxies combine to form supergalaxies; and so on. Thus from each rank on the hierarchic ladder we can step to the rank of the next higher order, and so forth to infinity. This type of cosmology has not yet found its place in modern theory; but the idea of an infinite amount of matter in an infinite space could, under suitable restrictions, satisfy the requirement of finite values of the gravitational forces in each volume element of an infinite space. Such a universe would be "static" in the sense that no large-scale changes in the distribution of matter and no unduly high velocities would occur.

An interesting feature of Finlay-Freundlich's presentation is the argument (p. 23) that the universe with a hierarchic structure is an "expanding" universe in the sense that the transition to a space of infinite volume has to be done by exhausting an infinite sequence of concentric shells, all centered around the observer's place. This also allows for the Doppler interpretation of the "red shift." I see no reason why the present cyclic-creative universe conception cannot accept the hierarchic cosmology, provided the experimental evidence is favorable. However, our cosmology as thus far developed is tied to the previously stated explanation of the red shift as evidence of the dissolution of matter according to some principle which still remains to be formulated.

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