Cosmology

THE SCIENCE OF THE UNIVERSE

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1 WHAT IS COSMOLOGY?

He has ventured far beyond the flaming ramparts of the world
and in mind and spirit traversed the boundless universe.
Lucretius (99–55 BC), The Nature of the Universe

THE UNIVERSE

From the outset we must decide whether to use *Universe* or *universe*. This is not so trivial a matter as it might seem. We know of only one planet called Earth; similarly, we know of only one Universe. Surely then the proper word is *Universe*?

The Universe is everything and includes us thinking about what to call it. But what is the Universe? Do we truly know? It has many faces and means many different things to different people. To religious people it is a theistically created world ruled by supernatural forces; to artists it is an exquisite world revealed by sensitive perceptions; to professional philosophers it is a logical world of analytic and synthetic structures; and to scientists it is a world of controlled observations elucidated by natural forces. Or it may be all these things at different times. Even more diverse are the worlds or cosmic pictures held by people of different societies, such as the Australian aboriginals, Chinese, Eskimos, Hindus, Hopi, Maoris, Navajo, Polynesians, Zulus. Cosmic pictures evolve because cultures influence one another, and because knowledge advances. Thus in Europe the medieval picture, influenced by the rise of Islam, evolved into the Cartesian, then Newtonian, Victorian, and finally Einsteinian pictures. The standard Western world picture of the late nineteenth century – the Victorian picture – was totally unlike the standard picture – the Einsteinian picture – of a hundred years later. Each society in each age constructs a different cosmic picture that is like a mask fitted on the face of the unknown Universe.

If the word "Universe" is used we must distinguish between the various "models of the Universe." Each model, religious, artistic, philosophical, or scientific, is one of many representations; and similarly with the models of different societies. Thus in the history of science we distinguish between the Pythagorean model, the Atomist model, the Aristotelian model, and so on. More precisely, we should say, the Pythagorean model of the Universe, the Atomist model of the Universe, the Aristotelian model of the Universe, and so on. Inevitably, the models receive the abbreviated titles: the Pythagorean Universe, the Atomist Universe, the Aristotelian Universe, ..., and we confuse ourselves by using the word Universe to mean "a model of the Universe."

The grandiose word Universe has a further major disadvantage. When used alone, without specification of the model we have in mind, it conveys the impression that we know the true nature of the Universe. We find ourselves, in the company of multitudes of others in the past, speaking of the Universe as if it were at last discovered and revealed. By referring to the contemporary model of the Universe as the "Universe," we forget that our contemporary model will undoubtedly suffer the same fate as its predecessors. Always, we mistake the mask for the face, the model universe for the actual Universe. Our ancestors made this

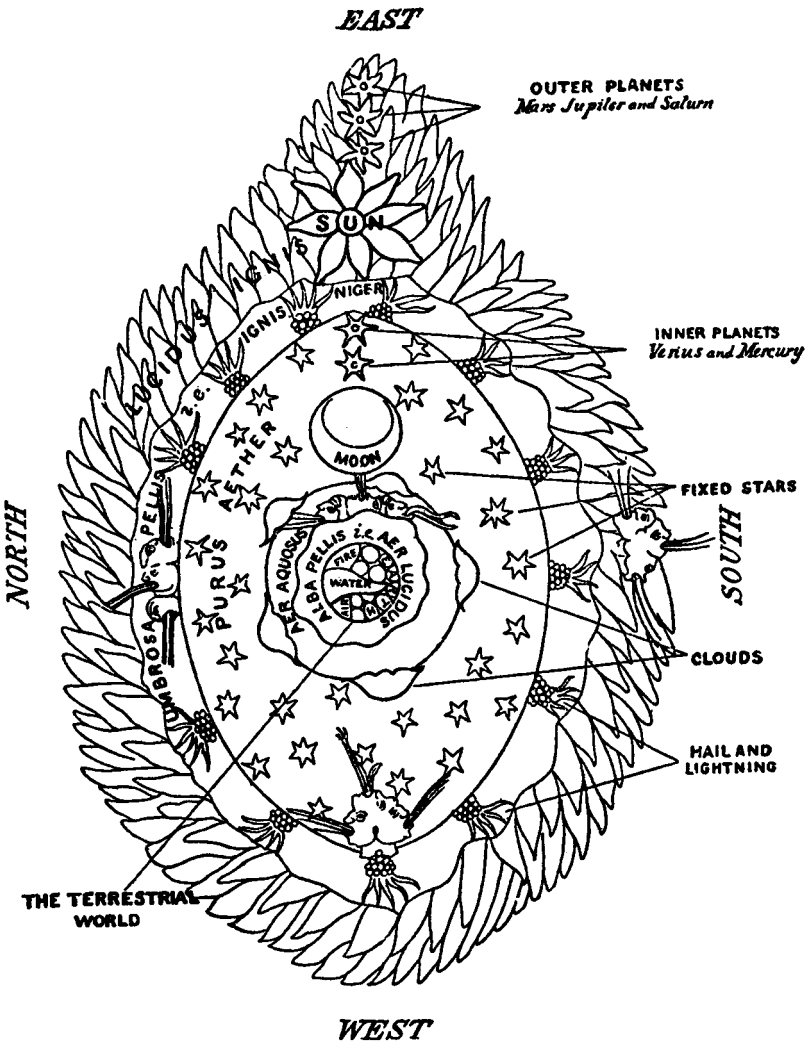

Figure 1.1. The universe according to Hildegaard of Bingen in Germany in the twelfth century. In her lifetime we see in her writings how the medieval picture evolved toward its climax in Dante's *Divine Comedy* (Figure 8.4). (Reproduced from the Wiesbaden Codex B as figure 2 in Charles Singer's "The scientific views and visions of Saint Hildegaard".)

mistake continually and most likely our descendants will look back and see us repeating the same mistake.

Because we cannot guess even in our wildest imaginings the true nature of the Universe, we may avoid referring to it directly by using the more modest word "universe." A universe is simply a model of the Universe (see Figure 1.3). Hence we may speak of the Pythagorean universe, the Atomist universe, Aristotelian universe, and so on, and each universe is a mask, a cosmic picture, a model that is invented, modified as knowledge advances, and finally discarded.

The word "universe," which we shall use, has the further advantage that it may be used freely and loosely without any need to

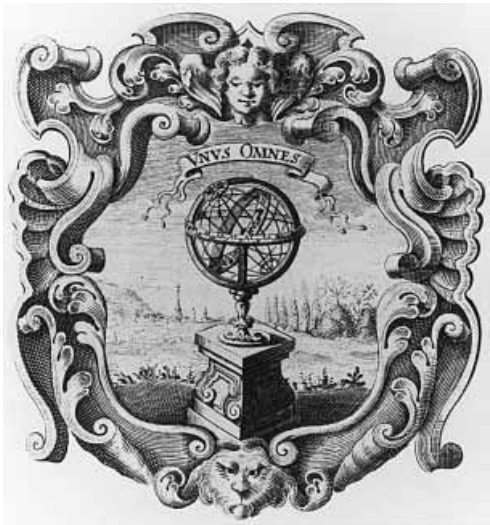

Figure 1.2. The Universe, *one and all-inclusive*, by Filippo Picinelli, 1694. In *The Cosmographical Glass: Renaissance Diagrams of the Universe* (1977), S. K. Heninger writes, ''We might conjecture that the artist, not bound by the constraint of cosmological dogma, felt free to engage in cosmological speculations of his own sort. He assumed a license to create his own universe. The worlds of Hieronymus Bosch, of Leon Battista Alberti, and of John Milton, to name a few examples, are the result.'' (Courtesy of the Henry E. Huntingdon Library, San Marino, California.)

remind ourselves constantly that the Universe is still mysterious and unknown. When the word ''universe'' is used alone, as in such phrases as ''the vastness of the universe,'' it denotes our present universe as disclosed by modern science.

COSMOLOGY

We search the sky, the Earth, and within ourselves, and forever wonder about the mystery of the universe: What is it all about? Why did it all begin? How will it all end? And are these questions meaningful? Always we ask the burning question: What is the meaning of life? Each of us echoes the words of Erwin Schrödinger – ''I know not whence I came nor whither I go nor who I am,'' and seeks the answer. The search is doomed to go astray from the beginning unless we familiarize ourselves with the

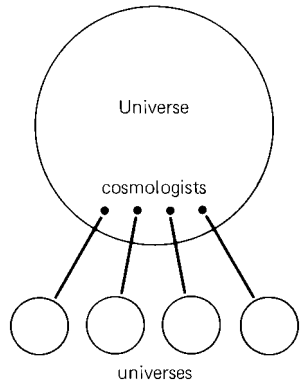

Figure 1.3. The Universe contains us who construct the many universes. Each universe is a model of the Universe. An intriguing thought is that each universe is the Universe attempting to understand itself.

universes of the past and particularly with the modern universe.

Cosmology is the study of universes. In the broadest sense it is a joint enterprise by science, philosophy, theology, and the arts that seeks to gain understanding of what unifies and is fundamental. As a science, which is the main concern in this book, it is the study of the large and small structures of the universe; it draws on knowledge from other sciences, such as physics and astronomy, and assembles a physically all-inclusive cosmic picture.

In our everyday life we deal with ordinary things, such as plants and flowerpots, and to understand these things of sensible size we explore the small-scale and large-scale realms of the universe. We delve deeply into the microscopic realms of cells, molecules, atoms, and subatomic particles, and reach far out into the macroscopic realms of planets, stars, galaxies, and the universe. We find that the very small and the very large are intimately related in cosmology.

Since the seventeenth century, knowledge has advanced rapidly and the number of sciences has grown enormously. Each science focuses on a domain of the universe and tends in the course of time to fragment into closely related new sciences of greater specialization. Originally, the characteristics

of living and nonliving things defined the differences between the broad domains of biology and physics. Each of these basic sciences, as it advanced, branched into new sciences, which in turn branched into more specialized sciences. Physics – once known as natural philosophy – has grown and branched into high-energy subatomic particle physics, low-energy nuclear physics, atomic physics, chemical physics, condensed-matter physics, biophysics, geophysics, astrophysics, and so on, and each has its own theoreticians, experimenters, and technicians. Biology – once the subject of naturalists of broad interests – with associated sciences such as botany, zoology, entomology, ecology, and paleontology, and so on, has grown and branched into molecular biology, biochemistry, genetics, and so on. And astronomy – once the subject in which everybody had equal knowledge (but not computing skill) – has branched into planetary sciences, the study of stellar structure and atmospheres, interstellar media, galactic astronomy, extragalactic astronomy, and the separate fields of radio, infrared, optical, ultraviolet, x-ray, and gamma-ray astronomy.

It is evident that the sciences divide the universe in order that each can construct in detail a domain of special knowledge. Science tears things apart into constituents of greater and greater specialization – often into smaller and smaller pieces – and devotes closer and closer attention to detail. A person studying in depth a branch of science becomes a specialist, engrossed in a maze of detailed knowledge, who knows much about a small domain of the universe and is comparatively ignorant of all the rest.

Cosmology is the one science in which specialization is rather difficult. Its main aim is to assemble the cosmic jigsaw puzzle, not to study in detail any particular jigsaw piece. While other scientists are pulling the universe apart into progressively more detailed pieces, the cosmologists are endeavoring to put the pieces together to see the picture on the jigsaw puzzle. Unlike all other scientists, the cosmologists take a broad view; like the impressionist painters they stand well back from their canvases so as not to see too much distracting detail.

Introductory cosmology is not a branch of astronomy. It is a "cosmopedia," more than an inventory of the contents of the universe, and is not a "whole-universe catalogue" of descriptive astronomical data. Cosmology is the study of the primary cosmic constituents, such as the origin and history of the chemical elements, and of space and time that form the frame of the expanding universe. The primary things of importance are scattered over large regions of space and endure over long periods of time. The origin and evolution of stars and galaxies, even the origin of life and intelligence, are important cosmic subjects. Subatomic particles, the role they play during the earliest moments of the universe, their subsequent combination into atoms and molecules that form the complexity of the living cell and our surrounding world, are all of cosmic interest.

At each turn, the issues of cosmology cause us to pause and reflect. Many subjects of vital importance are still obscure and not understood: how human beings acquired speech and large brains; and how they developed the ability to create abstract mental structures and think quantitatively. What determines the way that human beings think also determines the design they perceive in their universes. Human beings form a vital part of cosmology and represent the Universe perceiving and thinking about itself.

Who are the cosmologists? Professional cosmologists are relatively few; they are well-versed in mathematics, physics, and astronomy, and they study the evolution and large-scale structure of the physical universe. In general, however, whenever a person seeks to understand the Universe, that person becomes a cosmologist. When we stand back from the study of a specialized area of knowledge, or just step aside from our everyday affairs, and reflect on things in general, and try to see the forest and not just the trees, the whole painting and not

just the dabs of paint, the whole tapestry and not just the threads, we become cosmologists.

THE MAGIC UNIVERSE

Cosmology is as old as *Homo sapiens*. It goes back to a time when human beings, living in primitive social groups, developed language and made their first attempts to understand the world around them. Probably, hundreds of thousands of years ago, human beings explained their world by means of spirits. Spirits of all kinds, motivated by humanlike impulses and passions, activated everything. The early people projected their own inner thoughts and feelings into an outer animistic world, a world in which everything was alive. With supplications, prayers, sacrifices, and gifts to the spirits, human beings gained control of the phenomena of their world.

It was the Age of Magic, of benign and demonic spirits incarnate in plant, animal, and human form. Everything that happened was explained readily and easily by the passions, motives, and actions of ambient and indwelling spirits. It was an anthropomorphic world, of the living earth, water, wind, and fire, into which men and women projected their own emotions and motives as the guiding forces; the kind of world that children read about in fairy tales. From this "golden age" comes our primeval fear of the menace of darkness and the rage of storms, and our enchantment with the wizardry of sunrises, sunsets, and rainbows. For reasons not yet fully understood, human beings everywhere remained one species, and cultures (languages, social codes, belief systems, laws, technologies) interdiffused. Possibly, our moral codes of today, which regulate behavior in the family and society and determine in general what is ethically right and wrong, were naturally selected over long periods of time in primitive societies. Societies deficient in codes of mutual care and support among individuals had little chance of surviving.

THE MYTHIC UNIVERSE

At the dawn of history, ten or more thousand years ago, the early city-states attained more abstract concepts of the Universe. The magic universe evolved into the mythic universe. The long age of magic gave way to what might be called the Age of Theism. The spirits that had been everywhere, activating everything, amalgamated, retreated into remote mythic realms, and became powerful gods who personified abstractions of thought and language. James Frazer, in *The Golden Bough*, speculated on how magic among primitive people evolved into theism, and how the magic universe transformed into a variety of mythic universe:

> But with the growth of knowledge man learns to realize more clearly the vastness of nature and his own littleness and feebleness in the presence of it. The recognition of his helplessness does not, however, carry with it a corresponding belief in the impotence of those supernatural beings with which his imagination peoples the universe. On the contrary, it enhances his conception of their power. . . . If then he feels himself to be so frail and slight, how vast and powerful must he deem the beings who control the gigantic machinery of nature! . . . Thus in the acuter minds magic is gradually superseded by religion, which explains the succession of natural phenomena as regulated by will, passion, or caprice of the spiritual beings like man in kind, though vastly superior to him in power.

Much of mythology consists of primitive cosmic imagery (Figure 1.4). The Sumerian, Assyro-Babylonian, Minoan, Greek, Chinese, Norse, Celtic, and Mayan mythologies, to name only a few, are of historical interest because they illustrate mankind's earlier views of the universe. The creation myths, often difficult to interpret, are of particular interest (see Chapter 25).

Human beings at the cosmic center

No matter how powerful and remote they became, the mythic gods continued to serve and protect human beings, and men and women everywhere remained secure and of central importance in an anthropocentric universe. The universe was assembled about a center and human beings were located prominently at the center.

Anthropocentricity formed the basis of the Greek cosmology of an Earth-centered

Figure 1.4. *The Ancient of Days* by William Blake (1757–1827). "When he sets a compass upon the face of the depths" (Proverbs 8:27).

universe. The universe of Aristotle in the fourth century BC was geocentric (or Earth centered); the spherical Earth rested at the center of the universe and the Moon, Sun, planets, and stars, fixed to translucent celestial spheres, revolved about the Earth. The innermost region of heaven – the sublunar sphere between the Earth and the Moon – contained earthly and tangible things in an ever-changing state, and the outer regions of heaven – the celestial spheres – contained ethereal and intangible things in a never-changing state. The subsequent elaborations of this system, bringing it into closer agreement with astronomical observations, culminated in the Ptolemaic system of AD 140.

The Middle Ages (fifth to fifteenth centuries) were not so terribly dark as was once

supposed. The medieval universe from the thirteenth century to the sixteenth century was perhaps the most satisfying form of cosmology known in history. Christians, Jews, and Moslems were blessed with a finite universe in which they had utmost importance. By the Arab and European standards of those times it was a rational and well-organized universe that everybody could understand; it gave location and prominence to mankind's place in the scheme of things, it provided a secure foundation for religion and gave meaning and purpose to human life on Earth. Never before or since has cosmology served in so vivid a manner the everyday needs of ordinary people; it was simultaneously their religion, philosophy, and science.

The Copernican Revolution

The transition from the finite geocentric universe to the infinite and centerless universe is known as the Copernican Revolution. In the sixteenth century, Nicolaus Copernicus crystallized trends in astronomical thought that had originated in Greek science almost 2000 years before and proposed the heliocentric (or Sun-centered) universe. The Copernican heliocentric universe was soon transformed into the infinite and centerless Cartesian universe, which in turn was followed by the Newtonian universe. This revolution in outlook occupied the sixteenth and seventeenth centuries. The Copernican Revolution opened the way for modern cosmology.

But the spiritual universe, thought to be vastly more important than the physical universe, remained firmly anthropocentric. The spiritual universe was the "great chain of being," a chain of countless links that descended from human beings through all the lower forms of life to inanimate matter, and ascended from human beings through hierarchies of angelic beings to the throne of God. Mankind was the central link connecting the angelic and brute worlds. Even in an infinitely large physical universe, deprived first of the Earth and then of the Sun as its natural center, it was still possible to cling to old ideas that portrayed human beings as having central importance in the cosmic drama. The gods were ever mysterious and after the Copernican Revolution they became more mysterious than before.

The Darwinian revolution

In the middle of the nineteenth century came the most dreadful of all revolutions: the Darwinian Revolution. Human beings, hitherto the central figures in the cosmic drama, became akin to the beasts of the field. The gods who had attended and protected mankind for so long were cast out of the physical universe.

The anthropomorphic (magic) and anthropocentric (mythic) universes were wrong in almost every detail. The medieval universe has gone and with it has gone the great chain of being. Science at last is the victor, putting to flight the myths and superstitions of the past. We applaud the Renaissance (fifteenth to sixteenth centuries) with its revival of art and learning, we applaud the rise of the Cartesian and Newtonian world-systems in the seventeenth century, we applaud the Age of Reason (the Enlightenment of the eighteenth century) with its conviction in the power of human reason, and we applaud the Age of Science (seventeenth to twentieth centuries), and too easily forget the growing dismay of ordinary men and women in a universe that century by century progressively became more meaningless and senseless. With the decline and death of the old universes – anthropomorphic and anthropocentric – mankind was cast aimlessly adrift in an alien universe.

THE ANTHROPOMETRIC UNIVERSE

"Man is the measure of all things."
Protagoras (fifth century BC)

We believe that the universe is not anthropomorphic and not made in the image of human beings; it is not a magic realm alive with humanlike spirits. Also we believe that the universe is not anthropocentric with human beings occupying its center; we

are not the central figures; and the world is not controlled by gods and goddesses.

Instead, as Protagoras said, we are the measure of the universe, and this means that the universe is anthropometric. Let us try to understand what this means.

We have minds, or as some would say, we have brains. For our purpose it is not necessary to inquire into the nature of the mind–brain and attempt to probe its mysteries. It does not matter if we think the mind is a nonphysical entity of psychic activity or is a physical brain throbbing with bioelectrochemical activity. We have mind–brains into which information pours via the sensory pathways and from this information we devise in our mind–brains the Aristotelian, Stoic, Epicurean, Zoroastrian, Neoplatonic, Medieval, Cartesian, Newtonian, and all the other universes that have dominated human thought in different ages. We observe plants and flowerpots and other things and devise grand theories that relate and explain them, and these theories reside not in the things themselves but in our mind–brains. At each step in the history of cosmology, different universes prevail, and every universe in every society is a grand mental edifice that makes sense of the human experience. Each universe is anthropometric because it consists of ideas devised by human beings seeking to understand the things they observe and experience.

For those lost in the vast and apparently meaningless modern universe there is comfort in the realization that all universes are anthropometric. The Medieval universe was made and measured by men and women, although the medievalists themselves would have hotly denied the thought. The modern universe with its bioelectrochemical brains pondering over it is also human-made. Like the Medieval universe it will inevitably fade away in time and be replaced by other universes. The universes of the future will almost certainly differ from our modern version; nevertheless, they will all be anthropometric because "man is the measure of all things" entertained by man. The Universe itself, of course, is not human-made, but we have no true conception of what it actually is. All we know is that it contains us – the dreamers of universes.

COSMOLOGY AND SOCIETY

Cosmology and society are intimately related. Where there is a society, there is a universe, and where there is a universe, there is a society of thinking individuals. Each universe shapes the history and directs the destiny of its society.

This intimate relationship is most obvious in primitive cosmology where mythology and society mirror each other and the ways of gods and goddesses are the ways of men and women. Cruel people create cruel gods who sanction cruel behavior, and peaceful people create peaceful gods who foster peaceful behavior. The interplay between cosmology and society in the modern world is as strong as ever, if not stronger, but often in less easily recognized forms.

Without doubt the most powerful and influential ideas in any society are those that relate to the universe. They shape histories, inspire civilizations, foment wars, create monarchies, launch empires, and establish political systems. One such idea was the principle of plenitude, which can be traced back to Plato and has been enormously influential since the fifteenth century.

The principle of plenitude originated in the anthropocentric belief system that the universe is created for mankind by an intelligible supreme being. In its simplest form it states that a beneficent Creator has given to human beings for their own use an Earth of unlimited bounty. The more formal argument is as follows. The supreme being is without limitation because limitation implies imperfection and imperfection is contrary to belief. The unlimited potential of the supreme being is made manifest in the unlimited actuality of the created world. The Earth necessarily displays every form of reality in inexhaustible abundance. This is the principle of plenitude that saturates Western culture.

In the Late Middle Ages, telescopes disclosed the richness of the heavens, microscopes disclosed a teeming world of microorganic life, and the worldwide voyages by mariners opened up dazzling vistas of a vast and bountiful Earth. An unlimited abundance of every conceivable thing provided sufficient proof of the principle of plenitude. Europeans developed the principle, were guided by it, and have since exported it to the rest of the world.

Political ideologies were shaped by the principle of plenitude. The principle guaranteed endless untapped wealth and free enterprise flourished as never before. To offset depletion and escape population growth it was necessary only to push farther east and west to the glittering prizes of unravished lands. "The real price of anything is the toil and trouble of acquiring it" said Adam Smith. Go east! the streets are paved in gold. Go west! beyond the sunset lie lands of unharvested wealth. Husbandry of finite resources was not part of plenitude philosophy. People confidently believed that everything existed in unlimited abundance, and when anything became exhausted (such as the elimination of the bison herds, the extinction of the carrier pigeons and the great auks), they were taken by surprise and felt cheated.

The inevitable question followed, and has since echoed around the world: Why should inequality of wealth exist in a world of unlimited abundance? One answer came in the message from Karl Marx: in the *Communist Manifesto* we are told the less wealthy "have nothing to lose but their chains. They have a world to win." The principle of plenitude, which now lies buried deep in our cultural heritage and has been disseminated in various forms throughout the world, is unfortunately nothing but a cosmological myth.

Old ideas of cosmological breadth still dominate our everyday thoughts and many of these ideas are totally unsuitable in the modern world. We are, it seems, locked into the misguiding logic of obsolete universes that threaten to destroy us. We live in an age of crises – unchecked population growth, rapid depletion of resources, environmental and atmospheric pollution – and are mesmerized by prophecies of doom.

In 1776 the engineering firm of Boulton and Watt began to sell steam engines that, unlike previous steam devices, were powerful, quick-acting, and easily adapted for driving machinery of various kinds. This event more than any other ushered in the Industrial Revolution that has transformed our way of life. Many persons say that the ills of today are the direct consequence of the Industrial Revolution. But it is not the technologies that are to blame, but the ideas – the belief systems – that govern the use of the technology.

To make the point clear, let us imagine that space travelers encounter a planet that has been devastated by unbridled technology and become lifeless. In their investigations the space travelers cannot automatically assume that technology was the cause of the devastation. They must search for evidence indicating the nature of the beliefs of the vanished inhabitants. What inner mental world resulted in the outer ruined world? In their reports they will probably draw the conclusion that the ruined world is the result of an ancient cosmology, a cosmology founded on principles that in their saner moments the inhabitants had rejected and yet had driven them to their doom.

REFLECTIONS

1 *"I don't pretend to understand the Universe – it's a great deal bigger than I am." Attributed to William Allingham (1828–1889).*

- *The word* Universe *can be thought of as combining* Uni*ty and the di*verse. *The word* cosmos *means the harmonious whole of all reality. But what are the full meanings of unity, diversity, harmony, and reality?*

2 *In cosmology, there are two distinct languages: the first refers to* universes *and the second refers to* cosmologies. *In the first, cosmology is the study of many universes, and each universe is a model of the*

Universe. (Naturally in any age cosmology tends to be the study of the contemporary universe.) In the second, the Universe is studied by many cosmologies, and each cosmology is peculiar to a particular society. We have either a single cosmology studying many universes or a single Universe studied by many cosmologies. The first refers repeatedly to universes and the second refers repeatedly to the Universe. In this book we adopt the first method because it avoids using the word "Universe," except occasionally to make a point clear, and does not foster the illusion that the Universe is a known or even knowable thing.

3 Homo sapiens *has existed for about one million years. How did the early human beings view the world around them? "I shall invite my readers to step outside the closed study of the theorist into the open air of the anthropological field," wrote Bransilaw Malinowski in his book on the Tobriand Islanders of Melanesia. Through his observations and those of many other anthropologists studying different societies we find not primitive but sophisticated cultures and intricate languages existing everywhere. Truly primitive human beings, offering us insight into how our remote ancestors thought and lived, most probably exist nowhere in the world today.*

The world of primitive people was "possessed, pervaded, and crowded with spiritual beings," according to the Victorian anthropologist Edward Tylor in his book Primitive Culture. *He advanced the theory of animism. The early human beings projected their own emotions and motives into the surrounding world, and the world, thus animated, was able to explain almost everything that needed explaining. In the course of time, with the growth in language and abstract thought, the ambient spirits amalgamated into powerful nature spirits, godlings, gods, and goddesses.*

"The conception of gods as superhuman beings endowed with the powers to which man possesses nothing comparable in degree and hardly in kind has been slowly evolved in the course of history," wrote James Frazer in The Golden Bough. *Frazer discussed the evolution of animism into theism, and of how the management of "the gigantic machinery of nature" was handed over to the gods. He assumed as a basic premise that religion was born with the rise of the gods.*

4 *Religion in general is not easily defined. It seems to comprise emotions and ideas. The religious emotions experienced by individuals are much the same in all societies, whereas the religious ideas that evoke those emotions are peculiar to each society. Religious emotions are probably an integral part of human nature and essential in the survival of human societies. Theology is the study of religious ideas, and faith is the conviction in the absolute truth of those ideas. Invariably, the ideas have cosmological significance (see Chapters 2, 3, 4, 7, 8, 25, and 26). We note that everywhere in every age people in different societies have similar religious emotions, but have totally different religious ideas in whose absolute truth they have complete faith.*

Recognition of the universality of religious emotions and the diversity of religious ideas suggests that Frazer was wrong when he traced the roots of religion back to the birth of gods. Possibly religion is as old as Homo sapiens. *The error of confusing religious emotions with religious ideas seems quite common. When members of religious institutions insist on keeping their mythic beliefs, they unwittingly make the mistake of confusing theory with emotional experience and think that without primitive cosmology they cannot have religion. They fail to realize that scientific rejection of mythic cosmology does not bring science into conflict with religious experience. The modern theory of light as quanta of energy, for example, has not robbed us of the sensation of color and the emotional experience that accompanies color.*

Mythology is the study of myths. Myths apparently are ideas and stories that provide historical insights into the belief systems of other and often earlier cultures. Although credible in the belief systems in which they first originated, myths become incredible when transplanted into the belief systems of other cultures.

5 *Cosmological concepts have great influence for good and evil. Consider: "Thou shalt not suffer a witch to live." It is estimated that in the witch universe of the late Middle Ages (known as the Renaissance) and of the Age of Reason (known as the Enlightenment) about half a million men, women, and children confessed heresy and witchcraft under torture and were burned to death. It was said that heretics would burn forever in hell and the temporary anguish of fire on Earth was justified if they were saved from eternal fire of hell. Here is an instance of the maxim: "cruel people create cruel gods who sanction cruel behavior."*

- *"And the awful fact was that whenever you found one witch and used the just and proper instruments of inquiry, you inevitably found many others. Their numbers multiplied and seemed without limit. Male and female witches and their evilly spawned children were consumed by fire in mounting numbers, and still they multiplied" (E. Harrison,* Masks of the Universe*).*

"All Christianity, it seems, is at the mercy of these horrifying creatures. Countries in which they had previously been unknown are now suddenly found to be swarming with them, and the closer we look, the more of them we find. All contemporary observers agree that they are multiplying at an incredible rate. They have acquired powers hitherto unknown, a complex international organization and social habits of indecent sophistication. Some of the most powerful minds of the time turn from human sciences to explore this newly discovered continent, this America of the spiritual world" (Trevor-Roper, The European Witch Craze*).*

"The details they discovered are constantly and amply confirmed by other research workers – experimenters in confessional and torture chamber, theorists in library and cloister – leaving the facts still more securely established and the prospect even more alarming than before. Instead of being stamped out, the witches increased at a frightening rate, until the whole of Christendom seemed about to be overwhelmed by the marshaled forces of triumphant evil. To protest in any way against witch hunting as inhuman in a time of emergency was sheer lunacy, condemned by the popes as bewitchment and the result of consorting with devils" (E. Harrison, Masks of the Universe*).*

6 *Edward Milne in his last book* Modern Cosmology and the Christian Idea of God*, published posthumously in 1952, wrote: "There is a remarkable difference between physics and philosophy. On the one hand, physicists agree with one another in general at any one time, yet the physical theories of any one decade differ profoundly from those of each succeeding decade – at any rate in the twentieth century. On the other hand, philosophers disagree with one another at any one time, yet the grand problems of philosophy remain the same from age to age.... The man of science should be essentially a rebel, a prophet rather than a priest, one who should not be ashamed of finding himself in opposition to the hierarchy.... The hard-baked or hardboiled scientist usually holds that science and religion, whilst on nodding terms, have no immediate bearing on one another. On the contrary, one cannot study cosmology without having a religious attitude to the universe. Cosmology assumes the rationality of the universe, but can give no reason for it short of a creator of the laws of nature being a rational creator."*

7 *"Whereas philosophers and theologians appear to possess an emotional attachment to their theories and ideas that requires them to believe in them, scientists tend to regard their ideas differently. They are interested in formulating many logically consistent possibilities, leaving any judgment regarding their truth to observation. Scientists feel no qualms about suggesting different but mutually exclusive explanations for the same phenomenon" (John Barrow and Frank Tipler,* The Anthropic Cosmological Principle*, 1986).*

8 *The emergence of science, says Herbert Butterfield in* The Origins of Modern Science*, "outshines everything since the rise of Christianity and reduces the Renaissance and Reformation to the rank of mere episodes," and "looms so large as the real origin both of the modern world and the modern*

mentality that our customary periodisation of European history has become an anachronism and an encumbrance.'' Butterfield argues that science saved Europe from the mad witch universe. Not the humanities, not religion, but the sciences ended the witch craze of the Renaissance. Science was reaching out to a new universe more capable of distinguishing between the supernatural and the natural and of defining the limits of human control over nature.

9 *''Possibly the world of external facts is much more fertile and plastic than we have ventured to suppose: it may be that all these cosmologies and many more analyses and classifications are genuine ways of arranging what nature offers to our understanding, and that the main condition determining our selection between them is something in us rather than something in the external world'' (Edwin Burtt,* The Metaphysical Foundations of Modern Physical Science*, 1932).*

- *''Natural science does not simply describe and explain nature; it is part of the interplay between nature and ourselves; it describes nature as exposed to our method of questioning'' (Werner Heisenberg,* Physics and Philosophy*, 1958).*
- *In* The Discarded Image *(1967), C. S. Lewis writes: ''The great masters do not take any Model quite so seriously as the rest of us. They know that it is, after all, only a model, possibly replaceable.'' Later he continues: ''It is not impossible that our own Model will die a violent death, ruthlessly smashed by an unprovoked assault of new facts – unprovoked as the nova of 1572. But I think it is more likely to change when, and because, far-reaching changes in the mental temper of our descendants demand that it should. The new Model will not be set up without evidence, but the evidence will turn up when the inner need for it becomes sufficiently great. It will be true evidence. But nature gives most of her evidence in answer to the questions we ask her.''*

10 *In* The Great Chain of Being *(1936) by Arthur Lovejoy, we read: ''Next to the word 'nature,' the 'Great Chain of Being' was the sacred phrase of the eighteenth century, playing a part somewhat analogous to that of the blessed word 'evolution' in the late nineteenth.'' The great chain inspired the notion of ''missing links'' long before Darwin. The great chain of being, according to Lovejoy, was intimately associated with the principle of plenitude. ''Not so very long ago the world seemed almost infinite in its ability to provide for man's needs – and limitless as a receptacle for man's waste products. Those with an inclination to escape from worn-out farms or the clutter of urban life could always move out into a fresh, unspoiled environment. There were virgin forests, rich lodes waiting to be discovered, frontiers to push back, and large blank regions marked unexplored on the map.... It has, so far as I know, never been distinguished by an appropriate name; and for want of this, its identity in varying contexts and in different phrasings seems often to have escaped recognition by historians. I shall call it the principle of plenitude.''*

- *Garrett Hardin in ''The tragedy of the commons'' (1968) discusses how old myths and cosmological beliefs affect the way we live. Individuals strive to maximize their share of a common resource in the belief that ownership is a natural and even divine right. When herdsmen graze their beasts on common land, each strives to increase the size of his herd. Disease and tribal warfare maintain a state of equilibrium by limiting the numbers of persons and beasts below the capacity of the land. Then comes a more orderly and civilized way of life that, with diminished war and disease, places an increased burden on the commons. A herdsman now thinks, ''If I increase my herd, the loss owing to overgrazing will be shared by all, and my gain will exceed my loss.'' All herdsmen think this way and therein lies the tragedy. ''Each person,'' states Hardin, ''is locked into a system that compels him to increase his herd without limit – in a world that is limited.... Ruin is the destination to which all men rush.'' Unfortunately, most problems created by outdated cosmic myths (such as the Great Chain of Being, the principle of plenitude, and the freedom to reproduce without limit) do not have technical solutions.*

"A technical solution may be defined as one that requires a change only in the techniques of the natural sciences, demanding little or nothing in the way of change in human values or ideas of morality." The "concern here is with that important concept of a class of human problems which can be called 'no technical solution problems.'... My thesis is that the 'population problem,' as conventionally conceived, is a member of this class.... It is fair to say that most people who anguish over the population problem ... think that farming the seas or developing new strains of wheat will solve the problem – technically."

PROJECTS

1 Consider the old English prayer: "God help me in my search for truth, and protect me from those who believe they have found it."

• Consider also: In the *Memoirs of Zeus* by Maurice Druon, the goddess Mnemosyn declares "we would be better mirrors of the Universe if we were less concerned about our own image."

2 In the ancient world and in the Middle Ages astrology was the science of planets and stars, astrolatry was the worship of stars, and astromancy was the practice of soothsaying and divination by means of celestial configurations. We use the word biology for the science of living things and properly speaking we should use the word astrology for the science of stars. But astrology became corrupted and took the place of astrolatry and astromancy. Astrology now is the mythological belief that the affairs of human beings are influenced by the heavenly bodies.

Millions of people in America read the astrology (or rather the astromancy) columns in the daily newspapers; they find astromancy interesting and entertaining, for it is anthropocentric and connects human beings and the universe in ways that are meaningful to most people. Some persons take it seriously, and then, by modern standards, it becomes slightly ridiculous. But most people find it entertaining because it appeals to vestigial elements in our cultural heritage. Bart Bok, Lawrence Jerome, and 19 other leading scientists, in "Objections to astrology" (1975), vent their dismay: "Scientists in a variety of fields have become concerned about the increased acceptance of astrology in many parts of the world.... It should be apparent that those individuals who continue to have faith in astrology do so in spite of the fact that there is no verified scientific basis for their beliefs, and indeed that there is strong evidence to the contrary."

Discuss why astrology is still popular. Can it be that many persons find themselves in a largely meaningless universe from which their religions and philosophies have retreated? What can be done about this unhappy situation in which people find comfort in astromancy that science is resolved to eliminate? Sunday schools (in my day) did not arrest the flight from religion; will more introductory science courses arrest the flight from the scientific universe? Consider also Alfred Whitehead's statement in *Science and the Modern World*: "Nature is a dull affair, soundless, scentless, colourless; merely the hurrying of material, endlessly, meaninglessly."

3 Adam Smith's famous statement "The real price of anything is the toil and trouble of acquiring it" needs reexamining. In all undertakings with nature we should read the small print in the contract. This might disclose that the real price is paid by those who inherit the depletion and despoliation that follows. Are we already beginning to see the real price?

4 Give examples of problems that have no technical solution. Note that technical solutions, when they exist, often entail new problems. New drugs cure old diseases but add to the problem of population growth and may lead to greater suffering. Population growth has become a problem without technical solution, and requires, in Hardin's words, either a "change in human values or ideas of morality."

Do you think that colonizing space will technically solve the population problem? Sebastian von Hoerner, in "Population

explosion and interstellar expansion'' (1975), shows that this could solve the problem, with the present growth in birthrate, for at most only 500 years. The human space bubble, full of human beings, would expand faster and faster and in 500 years would expand at the speed of light. Each colonized planet would become more crowded and face the same problem that we now face on Earth. To what extent is the West with its technology, pharmacology, hygiene, and ideas of plenitude responsible for the alarming decrease in wild life and startling increase in human life?

5 Consider critically the syllogism:

> We are part of the Universe,
> we are alive,
> therefore the Universe is alive.

Consider also:

> The Universe contains us,
> we create universes,
> therefore no universe contains us.

6 Discuss the following examples of cosmic despair and hope:

''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 or feeling, can preserve a life beyond the grave; that all the labors of 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 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. Only within the scaffolding of these truths, only on the firm foundation of unyielding despair, can the soul's habitation be safely built'' (Bertrand Russell, *A Free Man's Worship*, 1923).

• ''The same thrill, the same awe and mystery, come again and again when we look at any problem deeply enough. With more knowledge comes deeper, more wonderful mystery, luring one on to penetrate deeper still. Never concerned that the answer may prove disappointing, but with pleasure and confidence we turn over each new stone to find unimagined strangeness leading on to more wonderful questions and mysteries – certainly a grand adventure!'' (Richard Feynman, ''The value of science,'' 1958).

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