Destiny of Life and Religious Attitudes, G.V. Coyne, in *Life as We Know It*, ed. J. Seckbach (Dordrecht: Springer Science 2005).

DESTINY OF LIFE AND RELIGIOUS ATTITUDES

GEORGE V. COYNE, S.J.
Vatican Observatory
V-00120 Vatican City State

1. Introduction

The general background to the topic I wish to address is to what extent religious thought can make a contribution to our scientific understanding of the origins and evolution of life in the universe derived from astrophysics and cosmology. And, on the other hand, to what extent can what we know from science about life influence our religious attitudes. This twofold question poses the serious risk of transgressing upon the epistemological independence of the various disciplines: theology, philosophy, astrophysics and cosmology, and creating, thereby, more confusion than understanding. As the discussion proceeds we must maintain a consistent posture of preserving the integrity of each of the disciplines.

Too often discussions of the relationship between science and religion are carried out in very general terms. Such discourse can be quite unfruitful for two reasons: (1) As compared to the natural sciences religion contains a larger measure of the subjective, of human experiences not totally verifiable by objective reasons. Such subjective experiences are not, of course, limited to religion. They are present in many areas of our lives. Nor need these experiences, religious or otherwise, necessarily conflict with reason. They simply are not limited to rational explanation. They go beyond what can be rationally justified. (2) While for the natural sciences we have a rather acceptable idea of what we mean by science, the very notion of religion is ill-defined. Does it mean worship? Does it mean being a "good person"? Does it mean accepting certain moral dictates that go beyond what is commonly accepted as good and bad? Does it mean accepting those dictates out of personal conviction or out of loyalty to a certain tradition? Does it mean believing in certain doctrines? Does it mean accepting a certain authoritative and hierarchical structure, i.e. being affiliated with a certain Church? To most of us religion would imply more of an affirmative than a negative answer to all of the above. And yet the situation is further complicated by the multiplicity of religions which differ among themselves, have even warred among themselves, over the responses given to such questions as the above. Even today, if we look at some of the main religious traditions: Islam, Judaism, Christianity, Buddhism, etc., we see not only vast differences among them, but enormous divisions within any one of the traditions.

The only way, therefore, that dialogue as a rational experience can take place is that, on

the part of religion, the dialogue be limited to the rational foundations for religious belief. Even then, the only way that any such dialogue could have universal significance is that we could assume that there existed common rational foundations across all religious traditions and that is simply not the case. It seems, therefore, that any fruitful dialogue requires that the rational basis for certain specific religious beliefs in certain specific religious traditions be confronted with what is known from the natural sciences. The natural sciences, in particular, have made great advances by adhering rigidly to canons of what is scientifically true. In fact, in recent years the norms for judging the scientific truth of a given theory of life's origins and evolution have been extended, it appears to me, in the direction of inviting dialogue with philosophy and theology. I would like now to discuss these epistemological methods of scientific astrophysics and cosmology with the view of applying that discussion to our knowledge of the origins of life in the universe.

Skeptics, dubious of ever being able to find a widely accepted definition of science, say that science is what scientists do. The element of truth in this statement is that science is not a univocal concept. It varies from one discipline to another, even, for instance, among the so-called hard sciences. But there is also sufficient commonality among them that the name "science" can be legitimately given to each analogically. Let us do this with astrophysics and cosmology. What are these disciplines? What do astrophysicists and cosmologists do? We begin with controlled data, that is, data which any other trained professional could independently verify. In astrophysics and cosmology these data are observations of the contents of the universe. The astronomical and astrophysical sciences in general, are unique in this regard. We observe; we do not perform controlled laboratory experiments. We can control the way we observe; but, unlike the other sciences, we cannot control what we observe. From the observed data we use mathematical analysis and physics to develop a model which best explains the data. We will later on discuss what constitutes a "best explanation." There are many assumptions involved in this process of applying mathematics and physics to developing our knowledge of life's origins in the universe. One of the principal ones is that it is valid to apply the laws of physics, which are derived from our knowledge of what happens on the earth, to the universe as a whole. At any rate the movement from observations to models is a continuously reciprocal process. We use the best model to determine what further observations must be made, we perfect the model with the new observations, etc. There is a constant going back and forth from observations to the model to the observations. It is important to note that in the very nature of this process of reciprocity we admit that we do not possess the truth. The most that we can expect is that we are continually approaching the truth. It is with this background that I would like to discuss the topic at hand.

It is arguably difficult to find a more heated topic of discussion than that concerning the origins and evolution of the universe, and especially of life and of intelligence in the universe, and whether such origins can be understand without evoking a Creator God. Responses range from the extremes of a Stephen Hawking or a Pope Pius XII to almost all conceivable intermediate positions. Hawking claims that, if his quantum cosmological theory of the origins of the universe without boundary conditions is correct, then we have no need of God. Pius XII attempted to claim that with Big Bang cosmologies scientists were coming to discover what had already been known from the Book of Genesis, namely that the universe had a beginning in God's creative action. In between we have such positions as evolutionary naturalism and episodic divine intervention. Evolutionary naturalists would claim that, although our scientific knowledge of evolution is limited, the

best explanation of the universe and all that it contains is through complexification in an expanding, evolving system in which both deterministic and chance processes play out their roles in a universe abundant with opportunities, 13.7 billion years old and containing 10^{22} stars. Those who profess episodic divine intervention would claim that divine activity is required, at least in some phases of the evolutionary process and, in particular at the occurrence of human life and intelligence, because natural processes alone are not adequate to explain the end result. What is one who is both a religious believer and a scientist to make of all of this?

Our attempts to understand the universe have as much to say about ourselves as they do about the universe. In fact, in us the universe can reflect upon itself and from our reflections there grows the conviction that we are part of that upon which we are reflecting. As soon as we set out with the powerful instruments for telescopic observations, together with those of mathematics and physics, to understand the universe and our place in it, we are made aware that there appears to be a destiny to life. Is there?

Modern cosmology, as well as ancient mythologies, cosmologies and cosmogonies, bear witness to the immense power which drives us humans in our continuous search for a deeper understanding of life. They also bear witness to the insufficiency of our search for understanding, of the need for something or someone out there, beyond oneself. From time immemorial we have always sought this further understanding in a person with whom we could converse, someone who shared our capacity to love and be loved and our desire to understand and to accomplish. Are such religious inclinations, if we may call them that, acceptable in a rational discourse on life's meaning?

2. Scientific Evidence for Universal Evolution

Let us take a sweeping view of a reasonable scientific picture of things. By reasonable I mean that, while we do not have all the answers, the following picture can stand up to any scientific critique. If we look today in infrared light at the center of Orion we see boiling gas and dust. If we look even closer up we see incandescent regions buried in that gas and with the Hubble Space Telescope we see the fine separation of blue gas and red gas in the midst of a rather chaotic structure. The fact is that stars are being born in this gas. And where the hottest, most massive and, therefore, brightest stars are already born, they are irradiating the gas, and it is giving off hydrogen alpha radiation. In this way we can identify star birth regions. The region of star birth in Orion is just a little part of our Milky Way. Our Milky Way, like most other spiral galaxies, measures 100,000 light years across and it contains about a hundred billion stars. It has several beautiful spiral arms and the sun is located in one of the outer arms, about two-thirds of the distance from the nucleus of our galaxy.

How is a star born? It happens by the laws of physics. A cloud of gas and dust, containing about 100 to 1,000 times the mass of our sun, gets shocked by a supernova explosion or something similar and this causes an interplay between the magnetic and gravity field. The cloud begins to break up and chunks of the cloud begin to collapse. And as any gas collapses, it begins to heat up; as it expands, it cools down. In this case the mass is so great that the internal temperature reaches millions of degrees and thus turns on a thermonuclear furnace. A star is born. Thermonuclear energy is the source whereby a star radiates to the universe. You need a very hot piece of the universe to do this, and so you can only get this thermonuclear furnace by having a cloud collapse and raise the temperature.

You can only get it, in other words, in stars, with one exception, namely, in the very hot early universe before galaxies or stars were born.

Stars also die. A star at the end of its life can no longer sustain a thermonuclear furnace and so it can no longer resist against gravity. It collapses for a final time, explodes and expels its outer atmosphere to the universe. This may happen nice and peacefully or it may happen in a violent cataclysmic explosion, called a supernova. The most famous of these is the Crab Nebula which has a pulsar at the middle as its dead star.

So stars are born and stars die. And as they die they spew left over star matter out to the universe. The birth and death of stars is very important. If it were not happening, you and I would not be here, and that is a scientific fact. In order to get the chemical elements to make the human body, we had to have three generations of stars. A succeeding generation of stars is born out of the material that is spewed out by a previous generation. But now notice that the second generation of stars is born out of material that was made in a thermonuclear furnace. The star lived by converting hydrogen to helium, helium to carbon, and if it were massive enough, carbon to oxygen, to nitrogen, all the way up to iron. As a star lives, it converts the lighter elements into the heavier elements. That is the way we get carbon and silicon and the other elements to make human hair and toe nails and all of those things. To get the chemistry to make amoebas we had to have the stars regurgitating material to the universe.

Obviously this story of star birth and death is very important for us. Out of this whole process around one star, which we call the sun, a group of planets came to be, among them the little grain of sand we call the Earth. An amazing thing happened with that little grain of sand when, in the 16^{th} and 17^{th} Centuries with the birth of modern science, we developed the capacity to put the universe in our heads. We do that by using mathematics and physics, and to some extent the laws of chemistry and biology. Since we have the capacity to put the universe in our heads, a further question comes to us. Where did galaxies come from? All of the material in the universe is concentrated in galaxies and their environs. Galaxies are the building blocks of the universe. Hubble Space Telescope has been able to photograph some of the most distant objects we have ever seen in the universe. They are at a distance of about ten billion light years from us. So we are seeing these objects as they were ten billion years ago. We think that Hubble is seeing proto galaxies. We see, for instance, a case of two blobs which seem to be merging and perhaps building up a galaxy. However, this is very controversial. We are uncertain about galaxy formation, whether it is bottom up with small units that build into a galaxy, or top down with a big cloud that collapses to form a galaxy, and then the stars form within it. Nevertheless, when we compare distant galaxies to nearby galaxies, we see clear differences in the stellar populations. Galaxies as they are born and age go through an evolutionary process. Galaxies are participating in the expansion of the universe. When we look at them on a large scale we see that they are not distributed homogeneously. There are large empty spaces and many dense alignments.

Let us now review what we know of the history of the expanding universe. As it aged, distances got larger in the universe. As this happened certain key events took place. Quarks combined to form elementary particles, which in turn formed atoms and then molecules. The universe became transparent and the cosmic background radiation came to be. Galaxies and stars were formed. The first microscopic life forms came to be after twelve billion years in a fifteen billion year old universe. Why did it take so long to make even an amoeba? We have already discussed one reason. We did not have the chemistry to make even an amoeba until we had had three generations of stars.

3. Origins of Intelligent Life

How did we humans come to be in this evolving universe? It is quite clear that we do not know everything about this process. But it would be scientifically absurd to deny that the human brain is a result of a process of chemical complexification in an evolving universe. After the universe became rich in certain basic chemicals, those chemicals got together in successive steps to make ever more complex molecules.

Finally in some extraordinary chemical process the human brain came to be, the most complicated machine that we know. I should make it clear that, when I speak about the human brain as a machine, I am not excluding the spiritual dimension of the human being. I am simply prescinding from it and talking about the human brain as a biological, chemical mechanism, evolving out of the universe.

Did this happen by chance or by necessity in this evolving universe? Was it destined to happen? The first thing to be said is that the problem is not formulated correctly. It is not just a question of chance or necessity because, first of all, it is both. Furthermore, there is a third element here that is very important. It is what I call "opportunity." What this means is that the universe is so prolific in offering the opportunity for the success of both chance and necessary processes that such a character of the universe must be included in the discussion. The universe is 13.7 billion years old, it contains about 100 billion galaxies each of which contains 100 billion stars of an immense variety.

We might illustrate what opportunity means in the following way. Einstein said that God does not play at dice. He was referring specifically to quantum mechanics, but it can be applied in general to his view of the universe. For him God made a universe to work according to established laws. This is referred to as a Newtonian Universe. It is like a clock that just keeps ticking away once you supply it energy. Today we might be permitted to challenge this point of view. We could claim that God does play at dice because he is certain to win. The point being made is that God made a universe that is so prolific with the possibilities for these processes to have success that we have to take the nature of the universe into consideration when we talk about how we came to be.

For 13.7 billion years the universe has been playing at the lottery. What do I mean by the lottery? When we speak about chance we mean that it is very unlikely that a certain event would happen. The "very unlikely" can be calculated in mathematical terms. Such a calculation takes into account how big the universe is, how many stars there are, how many stars would have developed planets, etc. In other words, it is not just guesswork. There is a foundation in fact for making each successive calculation.

A good example of a chance event would be two very simple molecules wandering about in the universe. They happen to meet one another and, when they do, they would love to make a more complex molecule because that is the nature of these molecules. But the temperature and pressure conditions are such that the chemical bonding to make a more complex molecule cannot happen. So they wander off, but they or identical molecules meet billions and billions of times, trillions if you wish, in this universe, and finally they meet and the temperature and pressure conditions are correct. This could happen more easily around certain types of stars than other types of stars, so we can throw in all kinds of other factors.

The point is that from a strictly mathematical analysis of this, called the mathematics of

nonlinear dynamics, one can say that as this process goes on and more complex molecules develop, there is more and more direction to this process. As the complexity increases, the future complexity becomes more and more predetermined. In such wise did the human brain come to be and it is still evolving. Can we call this process "destiny?".

Let us pause for a moment to review the degree of certainty which we can place in the above scenario. We certainly do not have the scientific knowledge to say how each living creature came to be in detail. We do not know precisely how each more complex chemical system came to contribute to the process of self organization which brought about the diversity of life forms as we know them today. Most importantly, we do not know with scientific accuracy the sufficient elements in nature to have brought about the unbroken genealogical continuity in evolution that we propose actually happened. There are, in brief, epistemological gaps which prevent natural science from saying that a detailed theory of biotic evolution has been proven. What we have presented is the most adequate account conceivable at this time considering the available empirical data. And that empirical data, with respect to biotic evolution, comes from various independent scientific enterprises, including molecular biology, paleontology and comparative anatomy.

How do we know we are on the path to the truth in the scenario of life's origins just described? In other words how do we judge what is the best way to explain life's origins. In the natural sciences there are a number of criterion whereby an explanation is judged to be best. I would list the principal criteria as the following: (1) verifiability, i.e., there is, at least in principle, a way of judging whether the explanation fits the data; (2) predictability, i.e., from data on past or present events it is possible to predict future events and then observe to see that the future events actually occur; (3) simplicity or economy, i.e., the least assumptions are made to get the greatest explanatory power; (4) beauty, i.e., the explanation has an aesthetic quality about it. Although, especially for the natural sciences, this may appear to be a very subjective criterion, almost all great scientific discoveries have benefited from its application. (5) unifying explanatory power; i.e. not only are the observations at hand explained but the attempt to understand is also in harmony with all else that we know, even with that which we know outside of the natural sciences.

It is this last criterion which I would like to discuss, since it appears to me to extend the epistemological nature of the natural sciences towards the realm of other disciplines, such as religious thought. Put in very simple terms this criterion is nothing else than a call for the unification of our knowledge. One could hardly be opposed to that. The problem arises with the application of this criterion. When is the unification not truly unifying but rather an adulteration of knowledge obtained by one discipline with the presuppositions inherent in another discipline. History is full of examples of such adulterations. It is for this reason that scientists have always hesitated to make use of this criterion. And yet, if applied cautiously, it appears to me to be a most creative one for the advancement of our knowledge.

The supposition is that there is a universal basis for our understanding and, since that basis cannot be self-contradictory, the understanding we have from one discipline should complement that which we have from all other disciplines. One is most faithful to one's own discipline, be it the natural sciences, the social sciences, philosophy, literature, religious thought etc., if one accepts this universal basis. This means in practice that, while remaining faithful to the strict truth criteria of one's own discipline, we are open to accept the truth value of the conclusions of other disciplines. And this acceptance must not only be passive, in the sense that we do not deny those conclusions, but also active, in the sense that we integrate those conclusions into the conclusions derived from one's own proper

discipline. This, of course, does not mean that there will be no conflict, even contradictions, between conclusions reached by various disciplines. But if one truly accepts the universal basis I have spoken of above, then those conflicts and contradictions must be seen as temporary and apparent. They themselves can serve as a spur to further knowledge, since the attempt to resolve the differences will undoubtedly bring us to a richer unified understanding.

The above discussion particularly applies when we are addressing fundamental and ultimate questions such as life's origins and meaning. Does the existence of intelligent beings in the Universe have a significance for understanding the Universe as a whole? Does our knowledge of God depend on our understanding of the Universe? In fact, a very strong piece of evidence that there is a universal basis for understanding is the very clear drive of the human being for meaning. This is seen clearly from the very dawn of human history where, with even a very primitive collection of data, our ancestors sought for the meaning of life in the physical universe, as well as in the events of their personal lives and those of society in general.

In summary, we note that the scientific and the religious approaches to the search for the meaning of life have for the most part been pursued in isolation from one another. In the past when they have met it has been mostly as antagonists. In recent times, however, there has been an increasing awareness of the need for dialogue in the quest for life's meaning. The common criteria of what is true in this search would be that the explanation be simple, aesthetically appealing, verifiable and that it have a unifying explanatory power. In practice these requirements for a good theory will not always agree among themselves and differing emphasis will be given to one or other criteria in the different disciplines.

Scientists are usually well aware of the limitations of their knowledge. Religious thinking also has its limitations. The excessively dogmatic approach which sometimes characterizes theology would do well to recognize this. I am not here referring to the faith dimension in religion. In fact, for the purposes of this discussion I am excluding that dimension which is transcendental and, if you will, a-rational (goes beyond reason) and I limit myself to a discussion of theology as a rational science. Theology must deal with the linguistic interpretation of written documents; it must interpret oral traditions; it must reconstruct history. It must establish a rational basis for accepting witnesses to historical events and it must determine when authority alone can be the source of certain truths. Above all there are the serious epistemological problems that arise from the relationship of theology to faith. Although theology is a science, a rational way of knowing in its own right, it is said to proceed from faith and to lead to an understanding of the faith (*fides quaerens intellectum*). This makes it subject to all of the false illusions that can arise from purely subjective behavior, and it must always struggle to separate those illusions from what is objectively true.

If we were to pursue the dialogue which I have outlined in this paper, we might soon come to see that a teleology and design in the universe, derived from a religious point of view, are not incompatible with cosmological models, derived from the scientific point of view. Or we would come to realize that inevitable tendency in the physical universe towards more complex structures is not incompatible with, for instance, human free will. In fact, as a deeper synthesis of the understanding of the whole unfolded through dialogue among the various disciplines it is very likely that the questions peculiar to each discipline would receive a more satisfactory answer. The important thing to realize is that in both the scientific and the religious approaches to understanding we are searching for the truth,

which we do not yet possess. But it is clear that evolution is an intrinsic and proper characteristic of the universe. Neither the universe as a whole nor any of its ingredients can be understood except in terms of evolution. And evolution is a daily happening. We, for instance, are constantly exchanging atoms with the total reservoir of atoms in the universe. Each year 98% of the atoms in our bodies are renewed. Each time we breath we take in billions and billions of atoms recycled by the rest of breathing organisms during the past few weeks. Nothing in my genes was present a year ago. It is all new, regenerated from the available energy and matter in the universe. My skin is renewed each month and my liver each six weeks. In brief, human beings are among the most recycled beings in the universe.

4. The Questioning Human Brain

Once we developed the capacity to put the universe in our heads, we became passionately interested in asking all kinds of questions. As an example of our scientific quest for life's meaning I would like to ask a one among many such questions. It is one which is fundamental to the origin of life on the Earth and perhaps elsewhere. Did our planetary system come about by a miracle? Absolutely not. Although we do not know everything about how it came about, we know that it happened in conjunction with the formation of the sun. Gas and dust were left over from the birth of the sun, and this gas and dust had to form into a disk by the law of physics to conserve angular momentum. Once all of this mass is concentrated into a disk, there is a much greater chance that the particles of gas and dust will collide and, in some cases, stick together. And, just like the rolling snowball effect, planetesimals, about 100 kilometers in diameter, are built up through accretion and finally planets are accreted from the planetesimals. We do not know everything about this process, but we know enough about it to know that it did not happen by a miracle. It happened by ordinary physical and chemical processes.

So, a further question arises: Did what we have just described happen elsewhere? First of all we look at those nearby stars that we suspect may be something like the sun. We have detected thus far more than 140 planets about other stars due to the center of mass motion of the star. That is an indirect way but a very solid one of detecting planets. We detect a wobble in the star due to the fact that there is mass outside of it so that the center of mass of the system is not at the geometrical center of the star. Furthermore, with the Hubble Space Telescope we have discovered disks around very young stars. We know for certain that they are very young stars by their spectra. We call the disks proto planetary because we have indirect evidence that the first planets have begun to form in the inner regions of the disk. We are beginning to see about other stars the process that we think formed the planets about the sun.

5. Implications for Religious Belief

How are we to interpret the scientific picture of life's origins in terms of religious belief. Do we need God to explain this? Very succinctly my answer is no. In fact, to need God would be a very denial of God. God is not the response to a need. One gets the impression from certain religious believers that they fondly hope for the durability of certain gaps in our scientific knowledge of evolution, so that they can fill them with God. This is the exact

opposite of what human intelligence is all about. We should be seeking for the fulness of God in creation. We should not need God; we should accept him when he comes to us.

The religious believer is tempted by science to make God "explanation." We bring God in to try to explain things that we cannot otherwise explain. "How did the universe begin?", "How did we come to be?" and all such questions. We sort of latch onto God, especially if we do not feel that we have a good and reasonable scientific explanation. He is brought in as the Great God of the Gaps. I have never come to believe in God, nor do I think anyone has come to believe in God, by proving God's existence through anything like a scientific process. God is not found as the conclusion of a rational process like that. I believe in God because God gave himself to me. That was not a miracle. It does make sense that there is a personal God who deals with me and loves me and who has given himself to me. I have never come to love God or God to love me because of any of these reasoning processes. I have come to love God because I have accepted the fact that he first made the move towards me. While reasoning has not been adequate to this experience, I find that it is profoundly coherent with all that I know by reason, including science. In fact, it is not only coherent but my scientific knowledge enriches that experience.

The scientific picture traced above in Sec. 3 deals with the questions of origins, of how what we observe and experience today came to be? The question of creation, and therefore of a God Creator, responds to the question of why is there anything in existence. Creation is not one of the ways whereby things originated as opposed to other ways that can be thought of, including quantum cosmology and evolutionary biology. The claim that all things are created is a religious claim that all that exists depends for its existence on God. It says nothing scientifically of how things came to be, although beautiful stories are told in the Book of Genesis, to elaborate on the dependence of all things for their existence upon God.

Having opened the Pandora's box of the Bible, let us elaborate a bit upon it. The Bible is a collection of writings by various authors at various epochs using various literary genres. And so it best serves reason if one speaks of a specific book rather than of the Bible in general. It is clear that the overall intention of the authors of Genesis is to evoke religious faith, an adherence to the God of Abraham, Isaac and Jacob, and not to teach science. There is simply no scientific teaching in Genesis. In the Judaic/Christian tradition, the roots of religious belief reach to 5,000 years before Christ with the prophet Abraham. But Modern Science cannot be dated before the 16^{th} or 17^{th} century, roughly from the time of Galileo and then through many others to Newton, with the discovery of the universal law of gravity, the differential calculus, etc. You may even wish to go back to the beginnings of the experimental method with Roger Bacon and others in the 13^{th} century. But, at any rate, the modern science that speaks to religion today is born much later than the religion to which it speaks. It has to be recognized that the religious tradition is historically much longer and to a certain extent has that richness of the past that modern science does not.

It is unfortunate that, at least in America, creationism has come to mean some fundamentalistic, literal, scientific interpretation of Genesis. Judaic-Christian faith is radically creationist, but in a totally different sense. It is rooted in a belief that everything depends upon God, or better, all is a gift from God. The universe is not God and it cannot exist independently of God. Neither pantheism nor naturalism is true.

But if we confront what we know of origins scientifically with religious faith in God the Creator, in the senses described above, what results? I would claim that the detailed scientific understanding of origins has no bearing whatsoever on whether God exists or not. It has a great deal to do with my knowledge of God, should I happen to believe he exists.

Let me explain.

Take two rather extreme scientific views of origins: that of Stephen Gould of an episodic, totally contingent and, therefore, non-repeatable evolutionary process as contrasted to a convergent evolutionary process such as that of Christian de Duve, in which the interplay of chance, necessity and opportunity leads inevitably to life and intelligence. In either case, it is scientifically tenable to maintain an autonomy and self-sufficiency of the natural processes in a natural world, so that recourse to God to explain the origins of all that exists, is not required. It is not a question of chance in nature, excludes God; destiny in nature requires God. In neither case is God required.

If, however, I believe in God then what nature tells me about God in one case is very different from what nature tells me about God in the other. Please note that I am not calling upon faith to adjudicate between contrasting scientific viewpoints. I do think that convergent evolution is more consistent with God's revelation of himself in the Book of Scripture, so that, as Galileo was fond of stating, the Book of Scripture and the Book of Nature speak of the same God.

If we take the results of modern science seriously, it is difficult to believe that God is omnipotent and omniscient in the sense of the scholastic philosophers. Science tells us of a God who must be very different from God as seen by the medieval philosophers and theologians. Let us ask the hard question. Could, for instance, God after a billion years in a fourteen billion year old universe have predicted that human life would come to be? Let us suppose that God possessed the theory of everything, knew all the laws of physics, all the fundamental forces. Even then could God know with certainty that human life would come to be? If we truly accept the scientific view that, in addition to necessary processes and the immense opportunities offered by the universe, there are also chance processes, then it would appear that not even God could know the outcome with certainty. God cannot know what is not knowable. The theologian, of course, would have a different answer. God is transcendent, outside of space and time. All events are simultaneous to him. But I have wished to stress God's immanence in a universe where the origins of life are a challenge to our knowledge.

This stress on God's immanence is not to place a limitation upon God. Far from it. It reveals a God who made a universe that has within it a certain dynamism and thus participates in the very creativity of God. Such a view of creation can be found in early Christian writings, especially in those of St. Augustine in his comments on Genesis. If they respect the results of modern science, religious believers must move away from the notion of a dictator God, a Newtonian God who made the universe as a watch that ticks along regularly. Perhaps God should be seen more as a parent or as one who speaks encouraging and sustaining words. Scripture is very rich in these thoughts. It presents, indeed anthropomorphically, a God who gets angry, who disciplines, a God who nurtures the universe. Theologians already possess the concept of God's continuous creation. I think to explore modern science with this notion of continuous creation would be a very enriching experience for theologians and religious believers. God is working with the universe. The universe has a certain vitality of its own like a child does. It has the ability to respond to words of endearment and encouragement. You discipline a child but you try to preserve and enrich the individual character of the child and its own passion for life. A parent must allow the child to grow into adulthood, to come to make its own choices, to go on its own way in life. Words which give life are richer than mere commands or information. In such wise does God deal with the universe.

These are very weak images, but how else do we talk about God. We can only come to know God by analogy. The universe as we know it today through science is one way to derive analogical knowledge of God. For those who believe modern science does say something to us about God. It provides a challenge, an enriching challenge, to traditional beliefs about God. God in his infinite freedom continuously creates a world which reflects that freedom at all levels of the evolutionary process to greater and greater complexity. God lets the world be what it will be in its continuous evolution. He does not intervene, but rather allows, participates, loves. Is such thinking adequate to preserve the special character attributed by religious thought to the emergence not only of life but also of spirit, while avoiding a crude creationism? Only a protracted dialogue will tell.

6. An Invitation to Think of Life as Destined

A much discussed question among cosmologists over the past two decades is the one arising from the so-called anthropic principle. Many distinctions are made concerning its true meaning; they range from the so-called "weak" principle, which essentially states that, as observers in the universe, we see the universe as related to us, to the "strong" principle, which requires a certain teleology intrinsic to the universe. For our purposes it is necessary to state only the following well-established cosmological facts: (1) the existence of the human being has required a fine-tuning of the physical constants and the laws of nature which we find empirically by scientific investigation in the universe; (2) there is no general cosmological theory which explains why those constants should have the precise values they do and the laws should be as they are.

Many examples of the fine-tuning I have referred to have been discussed. The argument is essentially the following one: of the many constants of nature, e.g., the velocity of expansion of the universe, the mass and charge of the electron as compared to the proton, the gravity constant, etc., the empirically measured value is so precise that had it been only slightly different (in general, one part in one million) it would have been impossible for human beings to have emerged. Why, therefore, are the values of all the constants so precisely what they are?

Let me give just a few examples. In expanding, since its beginning in a Big Bang, the universe has cooled to the current temperature of about three degrees Kelvin (absolute zero scale). In so doing it has followed the normal, well-known law for gases: as a given volume of gas collapses it heats up; as it expands it cools down. If the current temperature of the universe were much different than it is, the Earth would not be able to dissipate its energy and it would continuously heat up. Life on the surface of the Earth would not be possible beyond a certain temperature. Why is it that the temperature of the universe is just the value that it is, after having begun at millions of degrees? Examples of this kind could be multiplied many times over. For instance, if the energy levels in helium, carbon, and nitrogen were not precisely the values they are, the thermonuclear fusion processes which have given us the heavier elements could not have taken place. Without those heavier elements we would not be here. In fact, in order to have the right proportion of elements in the universe to form the human organism, three generations of stars were required. As we have seen in Sec. 2, the only way known to scientists to manufacture the heavier elements is in the thermonuclear furnaces of stars. As a star lives out its life it converts the lighter elements (hydrogen, helium, etc.) into the heavier elements (carbon, silicon, oxygen, etc.).

When it dies, it regurgitates this heavier material to the universe. The next generation of stars, born from this material, goes through the same life cycle, so that the universe is being constantly supplied with the heavier elements. To arrive at the chemical abundances required for the human organism three generations of stars had to perform in this way.

The cosmologist, of course, first seeks the answer in a general physical theory that will explain all of the values. No such theory exists. Next, we seek to explain the fine-tuning by statistics. Pure chance is ruled out because the probability that it could have happened by chance is unacceptable scientifically. The statistical argument then moves to the possibility that there are many universes, existing either simultaneously or successively. Each of these universes would have its own set of physical constants and of the laws of nature. If we have enough such universes, even an infinite number, then the probability that one such universe like ours would come to be is quite acceptable. However, none of these many universe proposals succeeds very well, either because data is lacking or they are not verifiable. Verifiability is an important and indispensable criterion of scientific validity. In the many-simultaneous-universes theory the universes are separated by distances greater than the light travel time for the total age of the universe, and, therefore, in principle non-verifiable because non-communicating. In the successive-universes hypothesis it is difficult to see how there could be any possible data which could verify the existence of a universe before the last Big Bang.

The inability to provide thus far a strictly scientific explanation to what is a strictly scientific problem, i.e., the anthropic principle, may be, according to the discussion above of the criterion of unifying explanatory power, an invitation to think that the explanation lies in a teleological consideration. It is important here to emphasis the word "invitation", so as to preserve the epistemological independence of the various disciplines. One is perfectly free to accept the invitation or not. One can stay firmly put within one's own discipline and continue to seek the answer there, uncontaminated by possible solutions arising elsewhere. But it seems to me that the invitation is a very real one and well-founded; it, therefore, also seems to me that it requires serious reasons to reject it. Those serious reasons must confront the long history of religious thought that there is a person at the source of the existence of the universe and that said person had a purpose or a design in "creating" the universe, a design which included, perhaps even centered upon, our existence.

What is being proposed, of course, is an invitation to return to an examination of the religious concept of the creation of the universe by God against the background of modern cosmologies. One of the most productive areas of research in modern cosmology is the application of quantum mechanics to an analysis of the origins and very earliest stages of the universe. It is important to note that our observational knowledge of the origins and early stages of the universe is very limited, we might say non-existent. But we can argue back quite rigorously to the physical conditions which characterized those stages by applying physics and mathematics to what we observe in the universe today. Amidst the myriads of such observational data there are three principal observations which emerge and which allow us to reconstruct the early universe: (1) from the measurements of distant galaxies and clusters of galaxies we know that the universe is expanding with very precise conditions; (2) from the measurement of the abundances of helium, lithium, deuterium and other light elements, we know that much of that material had to be created under extremely high temperature and density conditions in the early universe; (3) from a measurement of the current temperature of the universe, the so-called cosmic background radiation, we can

establish the temperature conditions of the early universe. When we combine all of this and other observations we can determine the age of the universe, its approximate mass and its mean density.

This summary of the results of modern cosmology represents an amazing feat in the combination of our knowledge of elementary particle physics and observational astrophysics. But the nagging questions remain: how did it all begin? when it began were there not certain initial conditions which determined how it would evolve? Did the universe really come to be in all its specificity from quantum fluctuations at its origin. Such considerations also suffer from problems of verifiability. The question also arises as to whether they really provide ultimate explanations.

It is precisely here, I believe, that religious thought can play a role in cosmology. Many of the concepts which are essential ingredients in the cosmological models have important implications in religious thought and those implications must also enrich cosmological thinking, so that the latter may have the greatest unifying explanatory power, a criterion for its veracity. In exploring these implications, however, it is essential that the fundamental significance of the concepts in the various disciplines not be confused. On the other hand the precise thrust of interdisciplinary dialogue is that a wider perspective will be gained on the fundamental reality by inter-relating the concepts arising from the diverse disciplines.

In the Hot Big Bang cosmological models the universe had a beginning. That beginning at time equals zero is a mathematical singularity. It cannot be addressed by classical mathematics or physics. To avoid that singularity it is claimed that quantum gravity must be applied at the extreme conditions of the universe's beginning. During this quantum gravity regime, however, the concept of time is inapplicable in any simple way. Most approaches require an origin of our specific universe from quantum fluctuations of a previous state: a collapsing previous state, a region of flat space-time, a previous black hole final state, etc. Such approaches, therefore, only address relative beginnings. They still leave us wondering about the origins of the previous state upon which the quantum fluctuations played out their game. What, if anything, do these quantum gravity considerations of the origin of the universe have to do with, for instance, the religious considerations of the creation of the universe in time and from nothing (*creatio ex nihilo*)?

Any attempt to simply identify the nothing (*nihilo*) of the religious thinker with the quantum fluctuations of one of the preexisting states would, to my mind, create nothing but confusion. But the one concept may illuminate the other. The thrust of the "in time" and "from nothing" for the religious thinker is to assert the total and exclusive dependence of the universe upon God the Creator. There was no rival to God preexisting before the universe began and in its beginning and continuation it depends on God. I cannot see how the scientific concepts deny or challenge the religious ones and they may even be illuminated by them. It would be equally confusing to deny the existence of God by stating that, since no boundary conditions were required for the quantum cosmological origin of the universe, God is not required. The God of the religious person is not a boundary condition for the universe. He is the creator, whatever content that notion of creator might have.

7. Summary

It makes us dizzy to contemplate billions of years in the evolving universe and then to think

that we are on a little planet orbiting a quite normal star, one of the 200 billion stars in the Milky Way. And the Milky Way is just one galaxy and not anything special among the billions of galaxies which populate the visible universe.

The search for life's meaning today is ever more human; it stimulates, provokes, questions us in ways that drive us beyond science in the search for satisfaction, while at the same time scientific data furnish the stimuli. In this context the best science to its great merit, does not pretend nor presume to have the ultimate answers. It simply suggests and urges us on, well aware that not all is within its ken. Freedom to seek understanding and not dogmatism in what is understood characterize the best of science's search for the origins and meaning of life. It is, in fact, a field where certainties lie always in the future; thus it is vital, dynamic and very demanding of those who seek to discover the secrets of life and their religious implications.