

The implications of scientific evolution to the semantics of the Christian faith

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Introduction

The general background to the topic I wish to address is to what extent can what we know from science about the evolution of life in the universe influence our religious attitudes. And, on the other hand, to what extent can religious thought make a contribution to our scientific understanding of the origins and evolution of life in the universe. This twofold question poses the serious risk of transgressing upon the epistemological independence of the various disciplines: theology, philosophy, astrophysics, biology 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, especially that between the natural sciences and theology. History has already shown how disastrous an effect the failure to preserve the integrity of the respective disciplines has had.

It is impossible, for instance, to deny that in the Age of the Enlightenment in the 16th and 17th centuries natural theology was a truly remarkable movement which demands our attention as the last historical instance of a major interaction between science and theology. The climax of this movement came with Isaac Newton. For Newton, for instance, there was no known reason for the fact that both the planets and their moons all move in almost the same plane; that this is not due to any necessity in nature appears from the observational fact that many comets in the solar system move in orbits that are strongly inclined to this plane. The lack of scientific reasons for such striking agreements, and his refusal to regard them as mere coincidences, made Newton conclude that “the motions which the planets now have could not spring from any natural cause alone but were impressed by an intelligent Agent,”¹ an agent whom Newton, as it were, salutes in terms of professional admiration, for “to adjust all these things together in so great a variety of bodies argues that cause to be not blind and fortuitous, but very well skilled in Mechanics and Geometry.”² And so was born the great “God of the Gaps,” the God who explains what science cannot explain.

In later times nature has been praised by poets for its captivating beauty or by philosophers for its challenging variety of phenomena demanding explanation. But never since has it been extolled by an almost unanimous chorus of scientists as hailing from the finger of God and, therefore, replete with evidences of his wisdom

and power. Astronomers, physicists and naturalists here joined ranks with Job and the Psalmist in recognizing God as the ultimate ground of everything in heaven and upon earth. For this was perhaps the most notable mark of natural theology. It did not originate in theology, but in science. It was not started by theologians trying from above to impress a religious perspective on science. It began as a grass root-movement among believing scientists who were convinced both that God's existence could be proved and some of His attributes described from below, that is, on the basis of the expanding world of scientific knowledge. This also convinced them that they had nothing to fear from the indubitable progress of science; for beyond the receding frontier between the known and the unknown there was no dark and dangerous abyss in which the religious mind might get lost, but just another territory to be surveyed in the search for new evidence of the Creator.

The end result, to my mind, is that in that age of Enlightenment and of the surge of scientific reasoning, most scientists, who were religious believers, were unreasonable in their approach to religious belief, since they sought to found their religious belief on purely rational grounds. This created then among some people, and continuing today among many, an unnecessary, to my mind, rift between science and religious belief. While philosophical and theological reasoning may serve as a prolegomena to religious faith and while faith does not of itself contradict any rational discourse, true religious faith is, for use of a better word, transcendent. It goes beyond the rational.

As an aside, atheism is an exercise in faith. I know of no rational proof that God does not exist. While it may defy logic to require a proof that something or someone does not exist, the long and profound history of religions throughout humanity's time on this earth should be approached more reasonably than happens among most modern atheists. To what extent this is an inheritance from the age of the Enlightenment and of the birth of modern science might stimulate our discussions.

The Nature of Religious Faith

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. First, 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. Secondly, 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, as I will soon discuss, in the direction of inviting dialogue with philosophy and theology, and specifically within Christianity.

Biblical Faith and Christianity

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, for instance, 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 16th or 17th century, 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 13th 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.

From ancient mythological views of the relationship of the gods to nature through the Golden Age of Greece, especially Plato, Aristotle and Archimedes, there was a development of conflicting views on the proper discourse on nature and the true relations between God and human beings.³ Into these unsettled times Christianity, with its inherited Biblical faith, emerged from its obscure origin in Palestine. At first sight it would seem that it must stay out of the philosophical battle as a non-combatant who was singularly uninterested in the scientific achievements of the Greeks. There is no treatise on cosmology in the New Testament and extremely few references to particular elements of the Greek account of the universe. All efforts are spent on the proclamation of the belief that the birth, life, death and resurrection of Jesus had radically changed the way in which the relations between God and the world should be envisaged.

From the religion of Israel Christianity also inherited the belief that the one Lord of the world is also its Creator.⁴ Time and again the Old Testament underlines the fact that the world is created. This is almost always understood in the sense that it has come into being independently of man and without human assistance. “Where were you when I laid the foundations of the earth?” (Book of Job, 38, 4) was God's question to Job. However, the Biblical doctrine of creation seems to be marked by a paradox. On the one hand there is a chasm between God and His creatures. Nothing in nature is divine. On the other hand, the created world is said to testify to the divinity of its creator. God must be present within it in such a way than man can recognize it as created. The beginning of the gospel of St. John indicates a solution of this dilemma. “In the beginning was the *logos*, and the *logos* was with God, and the *logos* was God. He was in the beginning with God. All things came into being through him, and without him not one thing came into being” (Gospel of John, I, 1). When the fourth Gospel opens by saying that “In the beginning was the *logos*,” it looks at first sight like the introduction to a Greek philosophical treatise. To use the word in a Christian context was an important step towards assimilating the conception of the world as a rational structure according to the basic tenet of Greek philosophy.

Despite its apparent ignorance of all matters scientific the New Testament presented

Christianity in a way that contained a number of seminal ideas out of which the future relationships between the scientific discourse on the laws nature and the religious belief that these laws revealed a divine plan would develop. The belief in One God implied a demythologization of the discourse on nature. That nature was created meant that its inner connections were established independently of the human mind which had to respect them when they were discovered. Finally the *logos* Christology made the idea of an all-permeating rationality at home in a religion which hailed Christ as the Lord of the World. It is difficult not to see a connection between this insight and the emergence of experimental methods in science.

The Nature of the Natural Sciences

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 the study of biological evolution against the background of cosmological evolution. What are these disciplines? What do these scientists do? We begin with controlled data, that is, data which any other trained professional could independently verify. From the observed data we use chemistry, physics and mathematics 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 developing our knowledge of life's origins and history in the universe. One of the principal ones is to assume that it is valid to apply the scientific laws 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 then 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.

The Science of Evolution

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 understood 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.⁵ 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.⁶ 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 increasing complexity 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? Let us first, however, review our scientific knowledge of life's origins.

The universe is 13.7 billion years old and it contains about 100 billion galaxies each of which contains on the average 200 billion stars of an immense variety. Since the Big Bang, 13.7 billion years ago, the universe has been expanding. Figure 1 shows one slice of that universe. We are at 13.7 billion light years distant from the Big Bang and with large telescopes we look back as far as we can. Note that the more distant we look in the universe the further back in time we are looking. So, when we look back 12 billion years we are seeing the young universe (Fig. 2). Except for a very few dots which are nearby stars of light these are all galaxies. This photograph is a very small piece of the total sky. By a statistical estimate we arrive at the count of about 100 billion galaxies in the universe and a total of about 20,000 billion billion stars.

The Andromeda galaxy (Fig. 3), our sister galaxy, is a typical spiral galaxy. It contains about 200 billion stars and measures 100,000 light years across. In a galaxy such as this stars are born. How is a star born? A cloud of gas and dust, containing about 100 to 1,000 times the mass of our sun begins to break up (Fig.4) and pieces of the cloud begin to collapse until the internal temperature reaches millions of degrees and thus turns on a thermonuclear furnace. A star is born. In the thermonuclear furnace a star lives 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. 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 (Fig. 5).

So stars are born and stars die. And as they die they spew left over star matter out to the universe (Fig. 6). From this gas of a supernova remnant another generation of stars will be born. The birth and death of stars is very important. If it were not happening, you and I would not be here. In order to get the chemical elements to make the human body, we had to have three generations of stars. To get the chemistry for life 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 (Fig. 7) and among them the little grain of sand we call the Earth (Fig. 8). An amazing thing happened on that little grain of sand. In the 16th and 17th Centuries with the birth of modern science we developed the capacity to put the universe in our heads (Fig. 9).

It is quite clear that we do not know everything about the process of biological evolution within the context of cosmological evolution. But the best scientific explanation to date is that through neo-Darwinian evolution 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 through three generations of stars, those chemicals got together in successive steps (Fig. 10) 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 (Fig. 11).

Let us now address a question which is fundamental to Christian faith. Did we come about by chance or by necessity in the evolving universe? From the best of modern science I respond by describing the dance of the fertile universe. For 13.7 billion years the universe has been dancing a fertile ballet. One of the ballerinas is chance. When we speak about chance we mean that it is not certain that a given event would happen. The "uncertainty" 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

are destined 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 you can consider 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 the process. As the complexity increases, the future complexity becomes more and more predetermined.

All of this is happening in a universe that is so fertile that the eventual outcome has a kind of predetermined nature. This predetermined nature may be represented by a tree, the Tree of the Universe (Fig. 12a). Everything that ever happened in the universe, from the making of quarks to the making of toenails, is all here. Even those processes that never succeeded, that failed, every dead leaf and dead branch has been conserved. Every meeting of molecules in inopportune circumstances is here. The tree has never been pruned. But blow a quiet breeze through this tree and what will you see? You will inevitably see something that resembles the bare trunk of a tree with certain branching to various forms of life and ending at the top with the human being (Fig. 12b). The result is inevitable because with a combination of chance and necessary processes in a very fertile universe with so many opportunities there is a narrowing down of the evolutionary process due to the nature of physics, chemistry, biology and nonlinear dynamics. Of course, I have simplified the tree. For biological systems it is really a bush (Fig. 13). If we truly accept that there are chance processes involved, then the branching of the tree could be somewhat different. But since complexity proceeds towards an ever more determined direction the trunk of the tree could not be very different. The paleontology, biology and chemistry behind all of this are quite uncertain, but it is clear that something like this would happen. Furthermore, scientists have found what appears to be a fine tuning of the universe towards human life. All of the laws of nature and the constants of nature have a well determined value which, if there were any small variation, would not permit life to be as we know it.

The Search for Truth

What degree of certainty can we place in our scientific knowledge of evolution in the universe? 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. In Figure 14 we present an example of such empirical data. We plot for each of the organisms represented the number of mutations that have taken place in the same protein molecule, cytochrome-c, over millions of years. It is clear that the more complex the organism the more mutations it has suffered. The best explanation is neo-Darwinian evolution.

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 semantics of the natural sciences towards the realm of other disciplines, especially to Christian faith. 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, as indicated in the Introduction. 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 and, therefore, of our faith.

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.

A Mutual Interaction: Science and the Semantics of Christian Faith

The above discussion particularly applies when we are addressing fundamental and ultimate questions such as life's origins and their meaning for our Christian faith. Does the existence of intelligent beings in the Universe have any 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. There are two topics which are of particular importance for the mutual interaction between science and Christian faith: (1) biological evolution and the nature of the human person; (2) scientific cosmology and the Christian faith in a Creator God. I would like to discuss each in turn.

A Mutual Interaction: Biological Evolution and the Person

For historical reasons, and not truly religious ones, biological evolution has been the enigma of religions. Fundamentalist religious thought denies it. Catholic

thought, as it has matured, accepts it as scientifically verified, but hesitates in how to deal with it. Why the denial and the hesitancy? Is it because God must be omnipotent and have everything under his control? The dynamism intrinsic in the universe in evolution seems to escape this omnipotence. I would like to discuss the most recent example of ‘Catholic hesitancy’ in light of the positive turn that it has taken.

A message of John Paul II on evolution was received by the members of the Pontifical Academy of Sciences on 22 October 1996 during the Plenary Session of the Academy being then held at the seat of the Academy in the shadow of St. Peter's Basilica and was subsequently made public.⁷ It stirred a vast interest among both scientists and the public, an interest that went well beyond the usual attention paid to Papal statements. While the encyclical of Pope Pius XII in 1950, *Humani Generis*, considered the doctrine of evolution a serious hypothesis, worthy of investigation and in-depth study equal to that of the opposing hypothesis, John Paul II states in his message:

Today almost half a century after the publication of the encyclical [Humani Generis], new knowledge has led to the recognition that the theory of evolution is no longer a mere hypothesis.

In order to set the stage for dialogue the message distinguishes in traditional terms the various ways of knowing. The correct interpretation of observed, empirical, scientific data accumulated to date leads to a theory of evolution which is no longer a mere hypothesis among other hypotheses. It is an established scientific theory. But since philosophy and theology, in addition to the scientific analysis of the empirical facts, enter into the formulation of a theory, we do better to speak of *several* theories. And some of those theories are incompatible with revealed, religious truth. It is obvious that some theories are to be rejected outright: materialism, reductionism, spiritualism. But at this point the message embraces a true spirit of dialogue when it struggles with the opposing theories of evolutionism and creationism as to the origins of the human person. And this is obviously the crux of the message.

The dialogue progresses in the following way: The Church holds certain revealed truths concerning the human person. Science has discovered certain facts about the origins of the human person. Any theory based upon those facts which contradicts revealed truths cannot be correct. Note the antecedent and primary role given to revealed truths in this dialogue; and yet note the struggle to remain open to a correct theory based upon the scientific facts. The dialogue proceeds, in anguish as

it were, between these two poles. In the traditional manner of Papal statements the main content of the teaching of previous Popes on the matter at hand is reevaluated. And so the teaching of Pius XII in *Humani Generis* that, if the human body takes its origins from pre-existent living matter, the spiritual soul is immediately created by God. And so, is the dialogue resolved by embracing evolutionism as to the body and creationism as to the soul? Note that the word "soul" does not reappear in the remainder of the dialogue. Rather the message moves to speak of "spirit" and "the spiritual".

If we consider the revealed, religious truth about the human being, then we have an "ontological leap", an "ontological discontinuity" in the evolutionary chain at the emergence of the human being. Is this not irreconcilable, wonders the Pope, with the continuity in the evolutionary chain seen by science? An attempt to resolve this critical issue is given by stating that:

The moment of transition to the spiritual cannot be the object of this kind of [scientific] observation, which nevertheless can discover at the experimental level a series of very valuable signs indicating what is specific to the human being.

The suggestion is being made, it appears, that the "ontological discontinuity" may be explained by an epistemological discontinuity. Is this adequate or must the dialogue continue? Is a creationist theory required to explain the origins of the spiritual dimension of the human being? Are we forced by revealed, religious truth to accept a dualistic view of the origins of the human person, evolutionist with respect to the material dimension, creationist with respect to the spiritual dimension? The message, I believe, when it speaks in the last paragraphs about the God of life, gives strong indications that the dialogue is still open with respect to these questions.

I would like to use the inspiration of those closing paragraphs to suggest that reflections upon God's continuous creation may help to advance the dialogue with respect to the dualistic dilemma mentioned above. We might say that God creates through the process of evolution and that creation is, therefore, continuous. Since there can ultimately be no contradiction between true science and revealed, religious truths, this continuous creation is best understood in terms of the best scientific understanding of the emergence of the human being, which I think is given in the following summary statement by the eminent evolutionary chemist, Christian de Duve, in his paper at the very Plenary Session of the Pontifical Academy of Sciences to which the Papal message on evolution was directed:

. . . evolution, though dependent on chance events, proceeds under a number of inner and outer constraints that compel it to move in the direction of greater complexity if circumstances permit. Had these circumstances been different, evolution might have followed a different course in time. It might have produced organisms different from those we know, perhaps even thinking beings different than humans.⁸

Does such contingency in the emergence of the human being contradict religious truth? Not, it appears to me, if theologians can develop a more profound understanding of God's continuous creation. 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 of spirit, while avoiding a crude creationism? Only a protracted dialogue will tell. The spirit of the closing paragraphs of the message of John Paul II on evolution is, I believe, an invitation to just such dialogue.

On several occasions Pope Benedict has given some indications of his views on evolution. At his general audience on 9 November 2005 he continued the series of talks in his catechesis of the prayer of the Church as derived from the Psalms.⁹ On this occasion he addressed the so-called "Pascal Hymn" of God's ancient chosen people (Psalm 135) which expresses the glory of God revealed in his creation as it celebrates God's love and fidelity to his alliance with his chosen people. The Pope uses the opportunity to speak indirectly of evolution.

"The first manifestation of this love and fidelity," says the Pope, "is to be found in God's creation: the heavens, the earth, the waters, the sun, the moon and the stars." "Consequently, there exists," affirms His Holiness, "a divine message, inscribed secretly in creation as a sign of God's love and fidelity . . ." The discourse then moves on to more modern concerns with allusions to evolution as the Pope, recalling the thoughts of St. Basil the Great, states: "There are some who, tricked by their deeply imbedded atheistic stance, imagine a universe with no guidance or order, as if floating along by sheer chance." The Pope, at that point departing from his written text, wonders about how many of those "some" among scientists today, drawn by atheism, see only chance in the world's unfolding, when we know from God's love and fidelity that he created the world out of love according to an intelligent design.

The Pope is speaking, of course, from a purely theological point of view in expressing God's love in creating a world which, to respect his fidelity, is orderly and does not evolve by sheer chance. I must recall at this point that neo-Darwinian evolution does not claim that the world evolves by sheer chance. The Pope says nothing about whether the natural sciences, respecting their own methodology, are capable of discovering God's intelligent design - and this is the critical issue. The Pope's position is that God's love and fidelity are at the source of his creation of the universe. If we use our best scientific knowledge of the "fertile" expanding and evolving universe to reflect upon the nature of God the Creator we will find, as the Pope suggests, that God is not primarily a "designer", an attribute which diminishes his magnificence. He is primarily a lover who in creating shares his love.

In his homily at the Easter Vigil liturgy of 2006 Pope Benedict again alludes to evolution when he suggests that the greatest "mutation" in the history of mankind is found in the Lord's Resurrection (Benedict XVI 2006).¹⁰ Through God's special intervention the human and the divine have been definitively united. These are, of course, religious and theological reflections but it is interesting that the Pope clearly adopts the language of evolution in expressing them.

A Mutual Interaction: Scientific Cosmology and Christian Faith

Let us now examine the interaction between scientific cosmology and Christian faith. What is being proposed, for instance, when we speak of the fine tuning of the universe may be 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. The inability to provide thus far a strictly scientific explanation to what is a strictly scientific problem, the fine tuning, may be an invitation to think that the explanation lies in a teleological consideration. It is important here to emphasize 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.

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.¹¹

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 the semantics of science and of Christian faith might fruitfully interact. 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.

The key to understanding the difference between creation and origins is the notion of change.¹² Changes in nature are the object of study for the natural sciences. From pure energy to matter, from hydrogen to hydrocarbons, from giant molecular clouds to star clusters, from single cells to organs, from amino acids to the human brain - these are all objects of investigation for the natural sciences. They all require an existing entity which changes. The natural sciences do not deal with the issue of existing at all; they deal with existing in a specific way and the changes in nature, which bring about specific ways of existing. Creation, on the other hand, speaks to the very existence of whatever exists. It does not speak to change. Creation does not deal with the chain of events which bring about a specific kind of being. It deals with the source of being of whatever exists. It does not address the evolution of one kind of being from another. To create, therefore, is not to work on or with some already existing material. Creation is not, therefore, a cause in the usual sense of the word. Or, if you wish, creation is the *complete* cause of all things. Such a complete causing is precisely what the act of creation is. Thus, to

create is to give existence to whatever exists in a specific way. To create does not mean to take “nothing” and make “something” out of it, in the sense of changing it from not being to being. To exist means to depend upon a source of existence. So, creation is not exclusively, nor even primarily, some distant event; to create is the continual, complete causing of the existence of whatever is.

So there can, in principle, be no necessary conflict between the doctrine of creation and any scientific explanation of origins. The natural sciences seek to account for change and the origins of change. Whether the changes described are biological or cosmological, have a beginning or not, are unending or temporally finite, they remain processes. Creation accounts for the existence of things, not for changes in things. So, given that something exists, how did life originate from this something is a scientific question. Why there is something rather than nothing is not a scientific question.

Religious perceptions of beginnings speak of creating out of nothing (*creatio ex nihilo*). There is a persistent confusion between cosmological and metaphysical/religious conceptions of “nothing.” Quantum cosmological views of the beginning of the universe speak of “vacuum fluctuations” and some are tempted to equate this “vacuum” with the “nothing” of the theologians. This is quite incorrect. The “vacuum” of quantum mechanics is something, if only a mathematical concept. To speak of “creation out of nothing” in philosophy or theology means that one is denying that any matter at all is changed or transformed into something else. The expression “out of nothing” or “from nothing” is, at its root, a denial of any material cause whatsoever in the act of creation.

In our discourse on beginnings we find it necessary to speak in a temporal framework. The creator is considered to be prior to what is created, but the priority is actually not temporal. The relationship is metaphysical not temporal. To be created out of nothing does not mean that the creature is *first* nothing and *then* something. It means that the creature has a dependent existence. Ancient philosophers of nature thought that the universe was eternal in the sense that it had no beginning. Some cosmologists propose that the very notion of temporality is a subsidiary concept. Neither view challenges the fundamental metaphysical truth that the universe is created. Some also propose that there is “eternal inflation,” an endless series of universes within universes. Still, all such universes would require creation in order to be. Nor is there a contradiction in the notion of an eternal created universe. For, even if the universe had no temporal beginning, it still would depend upon a creator for its very being. The radical dependence on a fundamental source of being as the “cause” of being is what creation means.

To affirm creation or to deny it on the basis of scientific theories represents a fundamental misunderstanding of both origins and creation. The Big Bang described by modern cosmologists is not creation. The evolution of life in the universe is not creation. Creation is not one of the ways in which the universe itself or life in it might have come to be. Creation speaks to the ultimate reason for the existence of all things. The natural sciences seek for the ways in which things came to be, their origins. It is mistaken, therefore, to conclude that there are implications for a creator if the universe is completely self-contained, with no singularities or boundaries, and completely described by a unified theory. One mistake which is made by those who use scientific theories to deny creation is the old error of thinking that to create means to be an agent cause of change.

The Limits of Our Knowledge and the Quest of Christian Faith

The best 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 as it seeks for the understanding which truly nourishes Christian faith. 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. It must above all in today's world confront our scientific knowledge of the evolution of life.

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 our scientific knowledge of life's origins and evolution. Or we would come to realize that inevitable tendency in the physical universe towards more complex structures is an invitation to think beyond science to a deeper synthesis of our understanding of scientific evolution and our Christian faith. 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 breathe 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.

How are we to interpret the scientific picture of life's origins in terms of religious belief? Does our knowledge of scientific evolution affect the semantics of Christian faith? It would be a mistake, I think, to require a belief in God to provide a scientific explanation of creation and evolution. 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 fullness 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? We seize upon God, especially if we do not feel that we have a good and reasonable scientific answer to such questions. He is brought in as the Great God of the Gaps. True belief in God does not come about by proving God's existence through anything like a scientific process. God is not found as the conclusion of a rational process like that. God gave himself to us. That was not a miracle. It does make sense that there is a personal God who deals with us and loves us and who has given himself to us. Faith consists in coming to love God because we have accepted the fact that he first made the move towards us. 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.

It is unfortunate that creationism has come to mean some fundamentalist, 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. Our scientific knowledge of evolution should definitely have a bearing on the semantics of Christian faith. Let me explain.

Take two rather extreme scientific views of origins: that of Stephen Gould¹³ 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,¹⁴ 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. 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 knew all of the laws of biology, chemistry and physics, knew all of 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 fertile 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 our scientific knowledge of the origins

of life must have a bearing upon the semantics of our Christian faith.

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.¹⁵ 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. In the semantics of religious faith God should perhaps 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. To integrate the results of 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 accept that 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.

¹ I. Newton, *Four Letters from Sir Isaac Newton to Doctor Bentley containing some Arguments in Proof of a Deity*, London, 1756. The most recent edition is in *The Correspondence of Isaac Newton*, ed. H. W. Turnbull, Cambridge, 1961, III, 233-256.

² *Ibid.*, 235.

³ Olaf Pedersen, *The Two Books*, eds; G.V. Coyne and T. Sierotowicz (Vatican City: Vatican Observatory Foundation, 2007), Chapter 1.

⁴ R. J. Clifford, "Creation in the Hebrew Bible," in *Physics, Philosophy and Theology*, eds: R.J. Russell, W. Stoeger, G.V. Coyne (Vatican City: Vatican Observatory Foundation, 1995) pp. 151-166.

⁵ S. Hawking, *A Brief History of Time* (London: Bantam Press, 1989).

⁶ For an excellent discussion of the contrasts between Pius XII and Georges Lemaître see Josef Turek, "Georges Lemaître and the Pontifical Academy of Sciences", Vatican Observatory Publications, 2, 167; see especially pp. 170-172.

⁷ John Paul II, The original message in French was published in *L'Osservatore Romano* for 23 October 1996 and an English translation in the Weekly English Edition of *L'Osservatore Romano* for 30 October 1996.

⁸ De Duve, C. "Life as a Cosmic Imperative," In: *The Origin and Early Evolution of Life*, (Vatican City: Pontifical Academy of Sciences) Part I, 311-331.

⁹ Benedict XVI, *L'Osservatore Romano*, 6 November 2005, pp. 1 ff.

¹⁰ Benedict XVI, *L'Osservatore Romano*, 17 April 2006, p. 1 ff.

¹¹ G.V. Coyne, "An Overview of Cosmic Evolution," in *Life in the Universe: From the Miller Experiment to the Search for Life on Other Worlds*, ed.: J. Seckbach (Dordrecht: Kluwer Academic Publishers 2004) 17-26.

¹² W.E. Carroll, "Thomas Aquinas, Creation, and Big Bang Cosmology, in *Science and Theology: Ruminations on the Cosmos*, ed. C. Impey (Vatican City: Vatican Observatory Foundation, 2003) 1-18. I am indebted to Carroll for much of the discussion in this section.

¹³ S.J. Gould, *The Structure of Evolutionary Theory* (Cambridge, Massachusetts: Harvard University Press, 2002).

¹⁴ C. de Duve, *Vital Dust* (New York: Basic Books 1995).

¹⁵ Augustine, *De Genesi ad litteram (The literal meaning of Genesis)*, trans. J. H. Taylor (New York: Newman Press 1982).