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The Big Bang, Stephen Hawking, and God

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I. The Big Bang

Cosmology is the study of the universe as a whole - its structure, origin, and development. The subjects cosmology addresses are profound, both scientifically and theologically. Perhaps the best way to define cosmology is in terms of the questions that it asks. Hugh Ross does an excellent job of stating these questions in his important book "The Fingerprint of God" (Second Edition, Whitaker House, 1989):

1) Is our universe finite or infinite in size and content?

2) Has this universe been here forever or did it have a beginning?

3) Was the universe created?

4) If the universe was not created, how did it get here?

5) If the universe was created, how was this creation accomplished, and what can we learn about the agent and events of creation?

6) Who or what governs the laws and constants of physics?

7) Are such laws the products of chance or have they been designed?

8) How do the laws and constants of physics relate to the support and development of life?

9) Is there any knowable existence beyond the apparently observed dimensions of our universe?

10) Do we expect our universe to expand forever, or is a period of contraction to be followed by a big crunch?

Let me begin by noting the relationship between my own research as a quantum chemist and the field of cosmology. On November 5, 1973, my research group published its first paper on interstellar molecules, the molecules that exist in those relatively empty regions between the stars. Our paper appeared in the journal Nature and was titled "Theoretical Support for the Assignment of X-ogen to the HCO+ Molecular Ion." The motivation for research on interstellar molecules has largely derived from the suggestion that these are the elementary materials from which life might have originated. My research group has continued its interest in interstellar molecules over the years, with many of our papers being published in the Astrophysical Journal, considered by some to be the premier journal in the field. Our most recent paper in the field, titled "Ion-Molecule Reactions Producing HC3NH+ in Interstellar Space: Forbiddenness of the Reaction between Cyclic C3H3+ and the N Atom," appeared in the November 10, 1999 issue of the Astrophysical Journal. Three more recent astrophysical papers involving my research group are in various stages leading to publication.

The idea that the universe had a specific time of origin has been philosophically resisted by some very distinguished scientists. Hugh Ross has done an excellent job of summarizing this resistance. Ross begins with Arthur Eddington (1882-1944), who experimentally confirmed Einstein's (1879-1955) general theory of relativity in 1919. Eddington stated a dozen years later: "Philosophically, the notion of a beginning to the present order is repugnant to me. I should like to find a genuine loophole." Eddington later said, "We must allow evolution an infinite amount of time to get started."

Albert Einstein's response to the consequences of his own general theory of relativity may be reasonably interpreted to reflect a possible concern about the peril of a confrontation with the Creator. Through the equations of general relativity, we can trace the origin of the universe backward in time to some sort of a beginning. However, to evade this seemingly inevitable cosmological conclusion, Einstein introduced a cosmological constant, a "fudge factor," to yield a static model for the universe. He longed for a universe that was infinitely old. In fairness, Einstein later considered this to be one of the few serious mistakes of his scientific career. However, even this concession must have been painful, as Einstein had a strong conviction that all physical phenomena ultimately should be accounted for in terms of continuous fields everywhere (see Max Jammer's 1999 book "Einstein and Religion").

Einstein ultimately gave at best reluctant assent to what he called "the necessity for a beginning" and eventually to "the presence of a superior reasoning power." But he never did embrace the concept of a personal Creator, a compassionate God who cares for men and women and children.

To understand the intensity of the objections to the idea that the universe had a beginning, an excursus may be helpful. Again following Hugh Ross, let us note the five traditional arguments for the existence of God. These arguments may be found in Augustine, and they were of course further elaborated by Thomas Aquinas. This may seem an unlikely starting point for our topic, but I think you will see as we proceed that

these arguments keep coming up. I am not going to take a position on whether these arguments are valid, but I will state them, because throughout current discussions of cosmology these arguments are often cited:

1) The cosmological argument: the effect of the universe's existence must have a suitable cause.

2) The teleological argument: the design of the universe implies a purpose or direction behind it.

3) The rational argument: the operation of the universe according to order and natural law implies a mind behind it.

4) The ontological argument: man's ideas of God (his God- consciousness, if you like) implies a God who imprinted such a consciousness.

5) The moral argument: man's built-in sense of right and wrong can be accounted for only by an innate awareness of a code of law - an awareness implanted by a higher being

So then, why has there been such resistance to the idea of a definite beginning of the universe? Much of it goes right back to that first argument, the cosmological argument. It may be useful to break down the cosmological argument into three parts:

(a) Everything that begins to exist must have a cause;

(b) If the universe began to exist, then

(c) The universe must have a cause.

You can see the direction in which this argument is flowing - a direction of discomfort to some physicists and others knowledgeable about these matters. Such a person was the Princeton physicist Robert Dicke, advocate of the infinitely oscillating theory of the universe, of which we will say more later. Dicke stated in 1965 that an infinitely old universe "would relieve us of the necessity of understanding the origin of matter at any finite time in the past."

In 1946 George Gamow (1904-1968), a Russian-born American physicist, proposed that the primeval fireball, the "Big Bang," was an intense concentration of pure energy. It was the source of all the matter that now exists in the universe. The Big Bang Theory predicts that all the galaxies in the universe should be rushing away from each other at high speeds as a result of that initial event, which some have described as a singular explosion. A possible future dictionary definition of the hot big bang theory encompasses the idea that the entire physical universe, all the matter and energy and even the four dimensions of time and space, burst forth from a state of infinite or near infinite density, temperature, and pressure.

The 1965 observation of the microwave background radiation by Arno Penzias (1933-) and Robert Wilson (1936-) of the Bell Telephone Laboratories (regrettably partially dismantled following the breakup of AT&T) convinced most scientists of the validity of the Big Bang Theory. Further observations reported in 1992 have moved the Big Bang Theory from a consensus view to the nearly unanimous view among cosmologists: there was an origin to the universe, perhaps 13-15 billion years ago. My former Berkeley colleague Joseph Silk and his coworkers gave a brief summary of the evidence for the Big Bang Theory in their February 17, 1995 review paper in Science magazine:

"The hot big bang model is enormously successful. It provides the framework for understanding the expansion of the universe, the cosmic background radiation, and the primeval abundance of light elements, as well as a general picture of how the structure seen in the universe today was formed."

Many scientists have been willing to comment on the philosophical consequences of the Big Bang Theory. For example, Arno Penzias, co-discoverer of the microwave background radiation and 1978 Nobel Prize recipient in physics, stated to the New York Times on March 12, 1978:

"The best data we have (concerning the big bang) are exactly what I would have predicted, had I nothing to go on but the five books of Moses, the Psalms, the Bible as a whole."

When asked more recently (in Denis Brian's 1995 book "Genius Talk") why some cosmologists were so affectionate in their embrace of the steady state theory (the idea that the universe is infinitely old) of the origin of the universe, Penzias responded: "Well, some people are uncomfortable with the purposefully created world. To come up with things that contradict purpose, they tend to speculate about things they haven't seen."

Perhaps the most amusing statement in this regard came from Cambridge University physicist Dennis Sciama, one of the most distinguished advocates of the steady state theory of the universe. Shortly after he gave up on the steady state hypothesis, Sciama stated: "The steady state theory has a sweep and beauty that for some unaccountable reason the architect of the universe appears to have overlooked." Of course we theoretical scientists have an abundance of excuses for why our cherished theories sometimes fail. But the notion of blaming our failures on the "architect of the universe" is very creative.

It is an unusual day when newspapers all over the world devote their front page headlines to a story about science. But that is exactly what happened on April 24, 1992. Announced on that date were the results of the so-called "big bang ripples" observations made by the cosmic background explorer (COBE) satellite of NASA. These ripples are the small variations in the temperature of the universe (about 2.7 degrees Celsius above absolute zero) far from heavenly bodies. These observations

were remarkably consistent with the predictions of the Big Bang Theory. The particular item that the London Times, New York Times, etc. seemed to pick up on was a statement by George Smoot, the team leader from the Lawrence Berkeley Laboratory. He said, "It's like looking at God." For obvious reasons, this headline captured the attention of thinking people throughout the world. In the euphoria that followed, Stephen Hawking described the big bang ripples observations as "the scientific discovery of the century, if not all time."

A somewhat more sober assessment of the big bang ripples observations was given one week later in the Los Angeles Times by Frederick Burnham, a science-historian. He said, "These findings, now available, make the idea that God created the universe a more respectable hypothesis today than at any time in the last 100 years."

George Smoot, leader of the COBE team of scientists, and I were undergraduate classmates at M.I.T. We both arrived in September of 1962 and graduated in June of 1966. I do not remember meeting George Smoot, but his last name was famous within the M.I.T. community from the first day of our freshman year. However, the fame of the name Smoot was not such as to suggest that George would become one of the world's most famous scientists 26 years following his graduation from M.I.T. Social fraternities were very popular during our years at M.I.T. In fact, about one-third of the undergraduate student body lived in these fraternities, which were located across the Charles River from M.I.T. Students were encouraged to join a fraternity in the week before the beginning of their freshman year. One of the "better" fraternities was named Lambda Chi Alpha. I visited Lambda Chi Alpha, but chose instead the best fraternity at M.I.T., namely Sigma Alpha Epsilon. For those of you who believe that American social fraternities excel primarily in drunkenness and debauchery, let it be noted that it was a full ten years later that I became a Christian.

Returning to the story, in 1958 Oliver R. Smoot, Jr., a new member of Lambda Chi Alpha, is said to have consumed an excessive amount of a common chemical reagent, namely ethyl alcohol. In a semi-conscious state, as the story goes, this Smoot, 5'7" tall, was rolled across the Harvard Bridge by his fraternity mates numerous times. On the next day, the Harvard Bridge was smartly adorned with Smoot markers. At every ten Smoots (an interval of about 56 feet) brightly painted markers noted the achievement. The total length of the Harvard Bridge was boldly proclaimed at both ends to be 364.4 Smoots plus one ear. During the 1963-1964 academic year, my fraternity decided that Smoot was getting far more credit than he deserved. One of our members, Fred Souk, declared that he was fully the equal if not the better of Smoot in every respect. So we went out in the dark of night, painted out the Smoot marks, and replaced them with Souk marks. Fred was a bit taller than Smoot, so the total number of Souks did not quite match the old Smoots. As it turned out, this action enraged the members of the Lambda Chi Alpha fraternity. The Souk marks were obliterated the very next night, and replaced with the venerable Smoots, which continue to this date to be repainted regularly on the Harvard Bridge. I must confess to some surprise that when I read George Smoot's semi-autobiographical popular book about the big bang ripples, titled "Wrinkles in Time," I found no mention of the most celebrated achievement associated

with his name, the immortal Smoot marks. However, on his web site George Smoot acknowledges that Oliver R. Smoot, Jr. is "a distant relative." Apparently, the only Smoots ever to attend M.I.T. were Oliver R. Smoot, Jr., George Smoot, and Oliver's son Stephen Smoot.

Not everyone was ecstatic about the Smoot observations that revealed the so-called "big bang ripples." Certainly, those who had argued so strongly and passionately for a steady state model of the universe did not appreciate the interpretation of these results. The latter group included most prominently two senior scientists, Sir Fred Hoyle (1915-), the British astronomer, and Geoffrey Burbidge (1925-), a distinguished astrophysicist at the University of California at San Diego.

We may continue to probe the philosophical implications of these big bang ripples observations by assessing a statement of Geoffrey Burbidge (made during a radio discussion with Hugh Ross) concerning these matters. Burbidge discounts the most obvious interpretation of the new experiments. He remains a strong advocate, in the face of seemingly overwhelming evidence, of the steady state theory. Remarkably, Burbidge stated that the COBE satellite experiments come from "the First Church of Christ of the Big Bang." Of course George Smoot took strong exception to this statement. In his popular 1993 book "Wrinkles in Time" Smoot does write cautiously "There is no doubt that a parallel exists between the big bang as an event and the Christian notion of creation from nothing." Burbidge did say something in the same interview that is indisputable, however. He predictably favored the steady state hypothesis and claimed that his view supports Hinduism and not Christianity. That is correct, because the steady state theory of the universe, were it to be true, would provide some support for the never ending cycles of existence taught by orthodox Hinduism.

Hugh Ross, an astrophysicist turned generalist, has written very persuasively on this topic. He again brings us to the philosophical implications. Ross states in his book "The Creator and the Cosmos" (Third Edition, Navpress, 2001) that:

"By definition, time is that dimension in which cause and effect phenomena take place. If time's beginning is concurrent with the beginning of the universe, as the space-time theorem says, then the cause of the universe must be some entity operating in a time dimension completely independent of and pre-existent to the time dimension of the cosmos. This conclusion is powerfully important to our understanding of who God is and who or what God is not. It tells us that the creator is transcendent, operating beyond the dimensional limits of the universe. It tells us that God is not the universe itself, nor is God contained within the universe."

Perhaps some readers are inclined to say "So what?" If you fall into that category, may I remind you that well more than one billion people on this planet believe either that God is the universe itself or that God is contained within the universe. If the Big Bang Theory is true, it creates serious philosophical problems for these world views. Some scientific discoveries do have profound metaphysical implications. An entire book on

this subject, titled "The Dancing Universe," (1997) has been written by Dartmouth College physics professor Marcello Gleiser. Without displaying any theistic sympathies, Gleiser confirms much of what Ross states above. His flow chart on page 303 labeled "A Classification of Cosmogonical Models" is of special interest. Gleiser asks the question "Is there a beginning?" to provide a primary sorting of world views. On the left side of Gleiser's diagram a positive answer to the above question leads via a particular path to creation by the sovereign God of the universe, as described in Genesis. On the right hand side, a "no" answer in regard to a beginning leads by another path to a rhythmic universe, as perhaps exemplified by the dance of Shiva in Hinduism. The resistance of several streams of Hinduism to the Big Bang Theory was recently highlighted at a symposium sponsored by the American Association for the Advancement of Science (AAAS) in Washington, D.C. (April 1999). In prepared remarks Hindu philosopher Anindita Baslev of Aarhus University in Denmark quoted from the ancient texts of her religion and summarily dismissed the discussions of big bang mechanics as "cosmological speculations."

Following the remarkable financial success of Stephen Hawking's 1988 book "A Brief History of Time," a number of distinguished physicists have tried their hands at the same literary genre. In this context I would like to quote from a book that I do not necessarily recommend to the general reader. This particular book is by a brilliant physicist, Leon Lederman, a Nobel Prize winner and also a gifted and dedicated educator. Lederman's book is called "The God Particle" and although the title sounds very appealing, the best material is in the first few pages. The remainder of the book is largely a case for the building of the SSC, the Super Conducting Super Collider, a proposed massive particle accelerator south of Dallas, Texas that was torpedoed by the U.S. congress in late 1993. Therefore, reading the book today is a bit of a Rip Van-Winkle experience. But the first section is wonderful; it is in fact a good summary of what I have attempted to say in this lecture thus far. Leon Lederman states:

"In the very beginning, there was a void - a curious form of vacuum - a nothingness containing no space, no time, no matter, no light, no sound. Yet the laws of nature were in place and this curious vacuum held potential. A story logically begins at the beginning. But this story is about the universe and unfortunately there are no data for the very beginning. None, zero! We don't know anything about the universe until it reaches the mature age of a billionth of a trillionth of a second - that is, some very short time after the creation in the Big Bang. When you read or hear anything about the birth of the universe, someone is making it up. We are in the realm of philosophy. Only God knows what happened at the very beginning."

In candid moments, outstanding cosmologists make statements rather similar to that quoted above. For example, Stephen Hawking states that "The actual point of creation lies outside the scope of the presently known laws of physics." M.I.T. professor Alan Guth, critical contributor to the "inflationary" understanding of the Big Bang Theory," is often considered to be the American counterpart of Hawking and has said analogously "The instant of creation remains unexplained."

II. Stephen Hawking

Stephen Hawking is probably the most famous living scientist. The tenth anniversary edition of his book,"A Brief History of Time," is available in paperback and I strongly recommend it. The book has sold in excess of 20 million copies. For such a book to sell so many copies is essentially unheard of in the history of science writing. For the past five years I have used "A Brief History of Time" as the centerpiece of a course that I teach for a select group of 15 University of Georgia freshman. For balance, the class also studies the novel "That Hideous Strength," the third book in the C. S. Lewis space trilogy. My course falls in the "Get to know the professor" category that is becoming popular in large public universities to offset the sense of anonymity that many entering freshmen feel.

An excellent film (1991, director Errol Morris) has been made about "A Brief History of Time," and we enjoy the film every year in my freshman seminar. There has even been another good book ("A Reader's Companion," Bantam, 1992) made about the film. Hawking has a wonderful sense of humor. He displays it in the foreword of the "Reader's Companion," stating "This is The Book of The Film of The Book. I don't know if they are planning a film of the book of the film of the book."

I want to begin our discussion of Stephen Hawking by saying something about his scientific research, without getting bogged down in details. Hawking has made his well-deserved scientific reputation by investigating in great detail one particular set of problems: the singularity and horizons around black holes and at the beginning of time. Now, every writer in this general area is convinced that if you encountered a black hole, it would be the last thing you ever encountered. A black hole is a massive system so centrally condensed that the force of gravity prevents everything within it, including light, from escaping. The reassuring thing is that, despite what our children see on the Saturday morning cartoons, no black hole appears to be in our neighborhood. That is, the closest black hole to planet earth is far more distant than could be traveled in the lifetime of a human being using conventional rockets.

Stephen Hawking's first major scientific work was published with Roger Penrose (a physicist very famous in his own right) and George Ellis (not as famous as Penrose and Hawking, but still very well known), during the period 1968-1970. They demonstrated that every solution to the equations of general relativity guarantees the existence of a singular boundary for space and time in the past. This landmark is now known as the "singularity theorem," and is a tremendously important finding, being about as close as we can get to a mathematical rationalization for the Big Bang Theory. Later, of course, Hawking began to carry out independent research, both by himself and with his own doctoral students and postdoctoral fellows. As early as 1973, he began to formulate ideas about the quantum evaporation of black holes, exploding black holes, "Hawking radiation," and so on. Some of Hawking's work is radical, exploratory, and even speculative in nature. However, by any reasonable standard Stephen Hawking is a great scientist. Even if time shows some of his more radical proposals to be incorrect, Hawking will have had a profound impact on the history of science.

The scientific centerpiece of "A Brief History of Time" would appear to fall in the speculative category of his research. In fact, I think it is fair to say that the scientific centerpiece of "A Brief History of Time" was not considered one of Hawking's most important papers prior to the publication of the book in 1987. I am referring to the "no boundary proposal" that Hawking published in 1984 in work with James Hartle, a physics professor at the University of California at Santa Barbara. Using a grossly simplified picture of the universe in conjunction with an elegant vacuum fluctuation model, Hartle and Hawking were able to provide a mathematical rationalization for the entire universe popping into existence at the beginning of time. This model has also been called the "universe as a wave function" and the "no beginning point." While such mathematical exercises are highly speculative, they may eventually lead us to a deeper understanding of the creation event. I postpone my analysis of the no boundary proposal for a few pages.

Hawking is certainly the most famous physicist in history who has not won the Nobel Prize. This has puzzled some people. Many people automatically assume that Professor Hawking has already won the Nobel Prize. Yet as of this writing (late 2002) he has not. This is probably because the Swedish Royal Academy demands that an award-winning discovery must be supported by verifiable experimental or observational evidence. Hawking's work to date remains largely unconfirmed. Although the mathematics and concepts of his theories are certainly beautiful and elegant, science waited until 1994 for rock solid evidence for even the existence of black holes. The verification of Hawking radiation or any of his more radical theoretical proposals still seems far off. In this context, we must recall that Albert Einstein was wrong about a number of important things scientific, especially quantum mechanics; yet we recognize him as one of the three great physicists of all time, along with Isaac Newton and James Clerk Maxwell. I should conclude this section by noting that a number of Nobel Prize Committees have shown themselves to be composed of rather savvy people, capable of compromise. So I would not be surprised to see the old gentlemen in Stockholm find a way to award the Nobel Prize in Physics to Stephen Hawking. Perhaps Hawking could share the prize with those responsible for the first observations of black holes.

III. And God

Those who have not read 'A Brief History of Time" may be surprised to find that the book has a main character. That main character is God. This was the feature of the book that the well known atheist Carl Sagan found a bit distressing. Sagan wrote the preface to the first edition of the book, but was less famous than Hawking by the time of arrival of the tenth anniversary edition, in which Sagan's preface does not appear. God is discussed in "A Brief History of Time" from near the beginning all the way to the crescendo of the final sentence. So let us try to put Hawking's opinions about God in some sort of a context. The context is that Stephen Hawking seems to have made up his mind about God long before he became a cosmologist.

Not surprisingly, the principal influence in Stephen's early life was his mother, Isobel. Isobel Hawking was a member of the Communist Party in England in the 1930's, and her son has carried some of that intellectual tradition right through his life. Incidentally, Hawking's fame is now such that he felt obligated to endorse one of the candidates in the 2000 United States presidential election. By the time he was 13, Hawking's hero was the brilliant agnostic philosopher and mathematician, Bertrand Russell. At the same age, two of Hawking's friends became Christians as a result of the 1955 Billy Graham London campaign. According to his 1992 biographers (Michael White and John Gribben), Hawking stood apart from these encounters with "a certain amused detachment." There is little in "A Brief History of Time" that deviates in a significant way from what we know of the religious views of the 13-year-old Stephen Hawking. However, we must note that in public questioning Hawking insists that he is not an atheist. And I am told by eyewitness observers that in recent years Stephen Hawking has appeared "once or twice a month" in an Anglican church with his second wife.

Perhaps the most important event of Stephen Hawking's life occurred on December 31, 1962. He met his future wife of 25 years, Jane Wilde, at a New Year's Eve party. One month later, Hawking was diagnosed with a debilitating disease, ALS or amyotrophic lateral sclerosis, known in North America as Lou Gehrig's disease. He was given two years to live at the time. That was nearly 40 years ago. I have seen three chemistry professor friends die of this terrible disease. My three friends lasted two, three, and five years, respectively, the last surviving on an iron lung for his last tortuous year. By anyone's estimation, the preservation of Stephen Hawking's life is a medical miracle. And he is a man of great personal courage.

At this point in his life, 1962, Stephen was by all accounts an average-performing graduate student at Cambridge University. I hasten to add that even average doctoral students at Cambridge, still one of the five great universities in the world, can be very good. Let me quote from his biographers, White and Gribbon, on this point:

"However, there is little doubt that Jane Wilde's appearance on the scene was a major turning point in Stephen Hawking's life. The two of them began to see a lot more of one another and a strong relationship developed. It was finding Jane Wilde that enabled him to break out of his depression and regenerate some belief in his life and work. For Hawking, his engagement to Jane was probably the most important thing that ever happened to him. It changed his life, gave him something to live for and made him determined to live. Without the help that Jane gave him, he would almost certainly not have been able to carry on or had the will to do so."

They married in July of 1965, somewhat past the expected date of Stephen Hawking's death. The fact that three children followed is indisputable evidence that Stephen was not dead. Hawking himself said in an interview shortly following the publication of "A Brief History of Time" that "what really made a difference was that I got engaged to a woman named Jane Wilde. This gave me something to live for." Jane Wilde is an interesting person in her own right. I think she decided early on to pursue an academic

discipline as far as possible from her husband. She received a doctorate for her research on the medieval lyric poetry of the Iberian Peninsula!

Jane Hawking is a Christian. She made the statement in 1986, "Without my faith in God, I wouldn't have been able to live in this situation (namely, the deteriorating health of her husband, with no obvious income but that of a Cambridge don to live on). I would not have been able to marry Stephen in the first place because I wouldn't have had the optimism to carry me through, and I wouldn't have been able to carry on with it."

The reason the book has sold more than 20 million copies, i.e., the reason for Hawking's success as a popularizer of science, is that he addresses the problems of meaning and purpose that concern all thinking people. The book overlaps with Christian belief and it does so deliberately, but graciously and without rancor. It is an important book that needs to be treated with respect and attention. There is no reason to agree with everything put forth in "A Brief History of Time" and you will see that I have a couple of areas of disagreement. It has been argued that this is the most widely unread book in the history of literature. I first began to prepare this material for a lecture in December 1992, because I was asked by a friend (John Mason) in Australia to come and speak on the subject. John wrote to me, "A great many people in Sydney have purchased this book. Some claim to have read it." So I encourage you to join the students in my University of Georgia class and become one of those who have actually read "A Brief History of Time."

Stephen Hawking has made some eminently sensible statements on the relationship between science and Christianity. For example, "It is difficult to discuss the beginning of the universe without mentioning the concept of God. My work on the origin of the universe is on the borderline between science and religion, but I try to stay on the scientific side of the border. It is quite possible that God acts in ways that cannot be described by scientific laws." When asked by a reporter whether he believed that science and Christianity were competing world views, Hawking replied cleverly "Then Newton would not have discovered the law of gravity." Dr. Hawking is well aware that Newton had strong religious convictions.

"A Brief History of Time" makes wonderfully ambiguous statements such as, "Even if there is only one possible unified theory (here he is alluding to the envisioned unification of our understandings of quantum mechanics and gravity), it is just a set of rules and equations. What is it that breathes fire into the equations and makes a universe for them to describe?" In a similar vein Hawking asks "Why does the universe go to the bother of existing?" Although Hawking does not attempt to answer these two critical questions, they make wonderful discussion topics for university students, and I have enjoyed using them for this purpose.

Hawking pokes fun at Albert Einstein for not believing in quantum mechanics. When asked why he didn't believe in quantum mechanics, Einstein would sometimes say things like "God doesn't play dice with the universe." On one such occasion, Niels Bohr is said to have responded "Albert, stop telling God what He can do." Hawking's adroit

response to Einstein is that "God not only plays dice. He sometimes throws them where they can't be seen." Of course, I like Hawking's response very much, having devoted my professional career to the study of molecular quantum mechanics.

For me (and for Hawking's now distinguished student Don Page; more on Professor Page later) the most precious jewel in "A Brief History of Time" reflects Hawking's interest in the writing's of Augustine of Hippo (354-430 A.D.). Hawking states "The idea that God might want to change His mind is an example of the fallacy, pointed out St. Augustine, of imagining God as a being existing in time. Time is a property only of the universe that God created. Presumably, God knew what He intended when He set it up."

The first time I read "A Brief History of Time," admittedly not critically, for the first 100 pages or so I thought, "This is a great book; Hawking is building a splendid case for creation by an intelligent being." But things then begin to change and this magnificent cosmological epic becomes adulterated by poor philosophy and theology. For example, Hawking writes on page 122 of the first edition, "These laws (of physics) may have originally been decreed by God, but it appears that He has since left the universe to evolve according to them and does not now intervene in it". The grounds on which Hawking claims "it appears" are unstated, and a straw God is set up that is certainly not the God who is revealed in time and space and history. What follows is a curious mixture of deism and the ubiquitous "god of the gaps." Stephen Hawking thus appears uncertain (agnostic) of his belief in a god of his own creation.

Now, lest any reader be uncertain, let me emphasize that Hawking strenuously denies charges that he is an atheist. When he is accused of atheism, he is affronted and says that such assertions are not true. For example, Hawking has stated "I thought I had left the question of the existence of a Supreme Being completely open. . . It would be perfectly consistent with all we know to say that there was a Being who was responsible for all the laws of physics." Stephen Hawking is probably an agnostic or a deist (a believer in an impersonal god) or something in between these two positions, his recent church attendance notwithstanding. He is certainly not an atheist and sometimes does not even appear very sympathetic to atheism.

One of the frequently quoted statements in "A Brief History of Time" is, "So long as the universe had a beginning, we would suppose it had a creator (the cosmological argument). But if the universe is really completely self-contained, having no boundary or edge, it would have neither beginning nor end: it would simply be. What place, then, for a creator?" Hawking's most famous statement is contained in the last paragraph of "A Brief History of Time." Perhaps attempting to balance the quotation just cited, Hawking writes "However, if we do discover a complete theory. . . . . then we would know the mind of God" As a person who has dedicated his professional life to science, I am personally sympathetic to this statement. John Calvin was correct is stating that "All truth is God's truth." But I think Professor Hawking is claiming too much here. I would modify his statement to say that if we had a unified, complete theory of physics, we

would know much more about the mind of God. To claim to know God comprehensively is beyond the capability of any human being.

IV. The Anthropic Principle

I feel the necessity to say something here about the anthropic principle. One statement of the anthropic principle would be that there are a number of fundamental constants (for example, the mass of the electron) or derived scientific parameters (for example, the dipole moment of the water molecule), any one of which changed just a little bit, would make the earth uninhabitable by human beings. In this regard a book that I strongly recommend is Hugh Ross's "The Creator and the Cosmos." Ross has a substantial discussion of the anthropic principle and demonstrates why many physicists and astronomers have considered the possibility that the universe not only was divinely caused, but in fact divinely designed.

One such person is Amherst College astronomy professor George Greenstein (a pantheist or something similar), who makes this statement: "As we survey all the evidence, the thought insistently arises that some supernatural agency, or rather Agency, must be involved. Is it possible that suddenly, without intending to, we have stumbled upon scientific proof of the existence of a Supreme Being? Was it God who stepped in and so providentially created the cosmos for our benefit?" Personally, I fear that Greenstein has gone, relative to Hawking, a little too far in the other direction. I do not think we have indisputable scientific proof of the existence of God. But I am convinced that we do have, in the big bang understanding, some very good evidence for the existence of the transcendent God of the universe.

Others have commented, sometimes inadvertently, on this evidence. A book I recommend is "Dreams of a Final Theory" by Steven Weinberg (1933- , Nobel Prize in Physics, 1979, and considered by many to be the greatest physicist of the last half of the twentieth century). Although Steven Weinberg is a staunch atheist, Chapter XI of his book is titled "What About God?" Therein Weinberg tells a story related by the Venerable Bede (672-735), English theologian and historian of the Pre-Middle Ages. In the story, a speech is made before King Edwin of Northumbria in favor of the adoption of Christianity. In this speech the term "banqueting hall" is used to describe the ordinary existence of human beings on planet earth. Weinberg's perceptive comment on the speech is, "It is an almost irresistible temptation to believe with Bede and Edwin that there must be something for us outside the banqueting hall." There must be something beyond strict reductionism or materialism. This view is echoed in the New Testament. For example, St. Paul wrote, "Ever since the creation of the world, God's eternal power and divine nature, invisible though they are, have been understood and seen through the things He has made" (Letter to the Romans 1:20). This is essentially what Steven Weinberg is attempting to describe - that almost "irresistible temptation" to believe in God.

It is relatively unusual that a physical scientist is truly an atheist. Why is this true? Some point to the anthropic constraints, the remarkable fine tuning of the universe. For example, Freeman Dyson, a Princeton faculty member, has said, "Nature has been kinder to us that we had any right to expect." Martin Rees, one of Hawking's colleagues at Cambridge, notes the same facts. Rees recently stated "The possibility of life as we know it depends on the values of a few basic, physical constants and is in some respects remarkably sensitive to their numerical values. Nature does exhibit remarkable coincidences." Science writer extraordinaire Paul Davies adds "There is for me powerful evidence that there is something going on behind it all. . . It seems as though somebody has fine tuned nature's numbers to make the Universe. . . The impression of design is overwhelming." Some scientists express surprise at what they view as so many "accidental occurrences." However, that astonishment quickly disappears when one sees purpose instead of arbitrariness in the laws of nature.

Against powerful logic, some atheists continue to claim, irrespective of the anthropic constraints, that the universe and human life were created by chance. The main argument seems to be "Since we human beings are here, it must have happened in a purely reductionist manner." This argument strikes me a bit like the apocryphal response of a person waking up in the morning to find an elephant in his or her bedroom. The individual in question concludes that this is no surprise, since the probability of the elephant being in the bedroom is a perfect 100%. Obviously this is a philosophical rather than scientific response to the situation.

A reply to this argument has been developed by the philosopher/historian William Lane Craig. The atheist's argument states that since we're here, we know every element of the creation must have happened by strictly material forces. Craig's philosophical counterargument, as reported by Hugh Ross, goes like this: Suppose a dozen sharpshooters are sent to execute a prisoner by firing squad. They all shoot a number of rounds in just the right direction, but the prisoner escapes unharmed. The prisoner could conclude, since he is alive, that all the sharpshooters missed by some extremely unlikely chance. He may wish to attribute his survival to some remarkable piece of good luck. But he would be far more rational to conclude that the guns were loaded with blanks or that the sharpshooters had all deliberately missed. Not only is life itself overwhelmingly improbable, but its appearance almost immediately (in geological terms), perhaps within as short a period as 10 million years following the solidification and cooling of our once-molten planet, defies explanation by conventional physical and chemical laws.

V. The No Boundary Proposal

Let us return to Hawking's no boundary proposal - the idea that the universe has neither beginning nor end. By treating the universe as a wave function, Hawking hopes to rationalize the universe's popping into existence 12-15 billion years ago. Critical to Hawking's research in this regard is the notion of imaginary time. The concept of imaginary time is a powerful mathematical device used on occasion by theoretical chemists and physicists. I remember clearly the day in the autumn of 1965, during my

Complex Variables class as a senior at M.I.T., when I learned that the result of contour integration was two pi i times the sum of the residues. For me, it was about as close to a revelation as I had received up to that time in my life. My closest colleague at Berkeley, Professor William H. Miller, in 1969 used imaginary time to understand the dynamics of chemical reactions, and it made him a household word in the world of science. The use of imaginary time is indeed a powerful tool.

Indulge me while I attempt to convey the essence of how imaginary time is exploited in theoretical physics and chemistry. One approaches a well defined problem, with all variables necessarily being real. This means, for example, real positions for all particles, real velocities, and so on. Real problems begin with all quantities real. Then one undertakes a carefully chosen excursion into the complex plane, making one or more variables complex. Subsequently we do some really cool things mathematically. Finally, all the variables revert to real values, and we find that something important has been mathematically derived that would have otherwise been impossible to prove.

Hawking and Hartle's no boundary proposal begins by adopting a grossly oversimplified model of the universe. Then the authors make time imaginary, and prove in their terribly restricted model that the universe has neither beginning nor end. The flaw in the exercise is that the authors never go back to real time. Thus the notion that the universe has neither beginning nor end is something that exists in mathematical terms only. In real time, to which we as human beings are necessarily attached, rather than in Hawking's use of imaginary time, there will always be a singularity, that is, a beginning of time.

In an obviously contradictory statement in "A Brief History of Time," Hawking actually concedes this point. What we are seeing in this situation is Hawking versus Hawking. I view the following statement as Hawking speaking in his right mind: "When one goes back to the real time in which we live, however, there will still appear to be singularities. In real time, the universe has a beginning and an end at singularities that form a boundary to space-time and at which the laws of science break down" (first edition, page 144). Only if we lived in imaginary time (not coming soon to a neighborhood near you!) would we encounter no singularities. In real time the universe was created ex nihilo 13-15 billion years ago.

With some trepidation, I will venture further. A case can be made that the Hartle-Hawking "no boundary proposal" is only of marginal scientific interest. The reasons for this conclusion might include: (a) the theory is a mathematical construct that has no unique empirical support; (b) the theory makes no verifiable scientific predictions that were not achieved earlier with simpler models; (c) the theory generates no significant research agenda. The primary purpose of the theory seems to be an attempt to evade the cosmological argument for the existence of God, via the claim that nature is self-contained and effectively eternal.

Science is primarily concerned with facts, not motive, and thus a complete scientific description of the creation does not necessarily rule out a providential account at the

same time. William Paley's famous design argument suggests that if you are taking a walk in the woods and find a watch on the path, you should not conclude that the watch just assembled itself - despite the fact that we can take the watch apart, look at every single part and completely understand how it works. We look at the watch on the path and prudently conclude that it was designed by some higher intelligence.

In "A Brief History of Time," Hawking states, "If the no boundary proposal is correct, He [God] had no freedom at all to choose initial conditions" This statement strikes me as a leap into irrationality. Why does Hawking find, within the functioning of the universe, aspects that appear to him to be limitations of God's power? This stems not from any attitude of an infinite God, but rather from the attributes of finite man. Namely, we as human beings are able to scientifically discern characteristics of the Creator only as they are related to that which is created, that which we can observe. This limitation of ours immediately reduces what might be infinite to the finiteness of our existence. Of course, Biblically, there is no problem in accepting divine constraints to divine options, if the Creator chooses to run the universe according to His stated and established laws. Divine tenacity to His own laws is, of course, the very essence of the Biblical God.

Another of Hawking's controversial statements needs to be addressed. Although it is not original with him, Hawking states: "We are such insignificant creatures on a minor planet of a very average star in the outer suburbs of one of a hundred billion galaxies. So it is difficult to believe in a God that would care about us or even notice our existence." I take a different position. In their recent writings, Hugh Ross and Guillermo Gonzalez (a professor of astronomy at Iowa State University) have demonstrated that our solar system, and in particular the sun and planet earth, are in fact quite extraordinary in many respects. Further, there is no compelling evidence to date that life exists elsewhere in the universe. Human beings, thus far, appear to be the most advanced species in the universe. Maybe God does care about us! Stephen Hawking surveys the cosmos and concludes that the principal characteristic of humankind is obscurity. I consider the same evidence and conclude that human beings are special. I must be quick to add that a Christian world view does not exclude the possibility of life, even sentient life, elsewhere in the universe. Precisely this possibility is addressed by C.S. Lewis in his two science fiction novels "Out of the Silent Planet" and "Perelandra."

Before moving on, two related issues need to be addressed. The first concerns the infinitely oscillating model of the universe, which posits a ceaseless sequence of big bang/big crunch pairs. This model, popularized by Robert Dicke, makes the universe effectively eternal. The infinitely oscillating universe model, as noted above, comports nicely with Hinduism's dance of Shiva. Since the hypothesized period between the present big bang and its imagined big crunch would be just one of an infinite number of such periods, any problems relating to the time scale that might be needed for evolution are resolved by the conclusion that our interval must be "just right." On many occasions when I have presented this lecture, the Q&A time includes a question concerning this cosmological model. Actually, this issue was resolved for most cosmologists in 1983 in a critical paper by Alan Guth (best known for his pioneering work on the inflationary features of the Big Bang Theory) appearing in the influential journal "Nature," volume

302, beginning on page 505. The title of Guth's paper tells the story: "The Impossibility of a Bouncing Universe." Therein Guth showed that even if the universe contained sufficient mass to halt the current expansion, any collapse would end in a thud, not a bounce. Incidentally, the weight of opinion among cosmologists has shifted over the past five years to the position that, short of direct intervention by God, the universe will continue to expand forever.

The second and perhaps most recent attempt to evade the (theistic) logical consequences of the fine tuning of the universe (anthropic constraints) is the proposal that there are an infinite number of universes. This proposal has been given wide attention through the popular 2000 book by Martin Rees entitled "Just Six Numbers." Rees's logic flows something like this: (a) he concedes that a universe like ours is overwhelmingly improbable; but (b) we know that God doesn't exist, or if He does He had nothing to do with the design of the universe; (c) thus there must be a near infinite number of universes; (d) ours just happens to be the universe that is just right for human life. Since no evidence for other universes is provided, Rees's argument is less than convincing, particularly for those who are prepared to consider the possibility of the existence of a personal God. The Rees proposal might be broadened a bit by adding that other universes might have their own forms of intelligent conscious life, very different from what is observed on planet earth. One could go further and state that there is no need for life in the proposed other universes to be based on carbon. John Polkinghorne has responded to these ideas as follows:

"Those who make such a claim are drawing a very large intellectual blank check on a totally unknown bank account. Consciousness seems to demand very great physical complexity to sustain it (the human brain is the most complicated physical system we have encountered). It is far from persuasive that there are many alternative routes to the generation of such complexity."

In his paper in the April 2001 issue of the journal "Science & Christian Belief" Rodney Holder critiques the postulation of the existence of many universes as an alternative to design. Holder states some of the problems associated with the postulate of an infinite number of universes;

(a) the existence of infinitely many universes depends critically on parameter choices;

(b) the probability that any universe in an ensemble is fine-tuned for life is zero;

(c) the physical realization of any ensemble will exclude an infinity of possibilities;

(d) the hypothesis is untestable and unscientific;

(e) The hypothesis is not consistent with the amount of order found in our universe, nor with the persistence of order.

In completing this discussion, I note that a Christian world view does not exclude the possibility of other universes. One of the great hymns of the Christian faith in fact begins with the words "O Lord my God, when I in awesome wonder, consider all the worlds Thy hands have made." However, a plausible scientific case for an infinite or near infinite number of universes has yet to be made.

VI. A Broader View

Does everyone agree with Stephen Hawking concerning the metaphysical consequences of recent cosmological discoveries? Certainly not. Alan Lightman, a MIT professor with no obvious theistic inclinations, states in his book "Origins: The Lives and Worlds of Modern Cosmologists" (Harvard University Press, 1990), "Contrary to popular myths, scientists appear to have the same range of attitudes about religious matters as does the general public." This fact can be established either from anecdotes or from statistical data. Sigma Xi, the scientific honorary society, conducted a systematic poll a few years ago which showed that, on any given Sunday, around 41 percent of all Ph.D. scientists are in church; for the general population the figure is perhaps 42 percent. So, whatever influences people in their beliefs about God, it does not appear to have much to do with having a Ph.D. in science. It is true in science, as well as in essentially all other professions, that after income levels reach perhaps $50,000. per year (in North America), further increases in salary may be correlated with higher percentages of agnosticism. In his 1998 paper in "Nature" Edward Larson showed that for incomes above $150,000. per year, belief in God falls off significantly. The same trend holds, for example, for lawyers at these income levels. This finding, of course, is consistent with the words of Jesus on the difficulty of a rich person entering the kingdom of heaven.

There are many prominent scientific counterexamples to Stephen Hawking. One is my former colleague at Berkeley for 18 years, Charles Townes (1915-). Townes won the Nobel Prize in Physics in 1964 for discovering the maser, which led quickly to the laser, surely one of the most important scientific advances of the twentieth century. In a statement from his recent book "Making Waves" (American Physical Society, 1995) Professor Townes appears to take dead aim on Hawking. Charles Townes states "In my view, the question of origin seems to be left unanswered if we explore from a scientific view alone. Thus, I believe there is a need for some religious or metaphysical explanation. I believe in the concept of God and in His existence."

Arthur Schawlow (1921-1999) was another Physics Nobel Prize winner (1981), honored for his work in laser spectroscopy. Schawlow was a professor at Stanford until his recent death and did not hesitate to identify himself as a protestant Christian. He stated, "We are fortunate to have the Bible and especially the New Testament, which tells us so much about God in widely accessible human terms." I view this statement as uniquely scientific, knowing that Professor Schawlow was convinced that his discoveries in laser spectroscopy were telling him something about God's handiwork. However, unlike the New Testament, Schawlow's research was difficult to express in "widely accessible human terms."

The other chaired Professor of Theoretical Physics at Cambridge (Cambridge is very stingy about handing out Professor titles; most tenured faculty members retire at the rank of Senior Lecturer) for much of Hawking's career was John Polkinghorne, a nuclear physicist. He left the chair of mathematical physics at Cambridge in 1979 in order to train for the ordained ministry of the Church of England. Upon ordination, Polkinghorne became a parish priest for five years. He returned to Cambridge in 1986 as Dean of Trinity Hall and subsequently President of Queens' College. I am very familiar with the grounds of Queens' College, as it is immediately adjacent to St. Catherine's College, where I stay in Cambridge courtesy of my longtime collaborator, Professor Nicholas Handy. John Polkinghorne's statement of belief is straightforward: "I am a Christian believer and believe that God exists and has made Himself known in human terms in Jesus Christ."

Probably the world's greatest living observational cosmologist is Allan Sandage. Sandage works in Pasadena, California at the Carnegie Observatories. In 1991 he received the Crafoord Prize, given by the Royal Swedish Academy every six years for cosmology and worth the same amount of money as the Nobel prize (there is no Nobel prize given for cosmology). Sandage has been called "the grand old man of cosmology" by the New York Times and is viewed as the successor to his mentor, Edwin Hubble (1889-1953), who is considered the father of modern cosmology.

At the age of about 50, Sandage became a Christian. Sandage has stated "The nature of God is not to be found within any part of the findings of science. For that, one must turn to the Scriptures." When asked the famous question regarding whether it is possible to be a scientist and a Christian, Sandage replied, "Yes. The world is too complicated in all its parts and interconnections to be due to chance alone. I am convinced that the existence of life with all its order in each of its organisms is simply too well put together."

Of Hawking's two earliest collaborators (1970, the singularity theorem), Roger Penrose seems to be some sort of an unconventional theist, while George Ellis is a Christian. Ellis is Professor of Applied Mathematics at the University of Cape Town, South Africa. In the book "Quantum Cosmology and the Laws of Nature," Ellis states his position with respect to ultimate questions:

(1) God is the creator and sustainer of the universe and of humankind, transcending the universe but immanent in it; (2) God's nature embodies justice and holiness, but is also a personal and loving God who cares for each creature (so the name "father" is indeed appropriate); (3) God's nature is revealed most perfectly in the life and teachings of Jesus of Nazareth, as recorded in the New Testament of the Bible, who was sent by God to reveal the divine nature, summarized in "God is Love;" (4) God has an active presence in the world that still touches the lives of the faithful today.

One of the scientists closest to Stephen Hawking and prominent in the movie about "A Brief History of Time" is Donald Page. Page is Professor of Physics at the University of

Alberta, where he hosted my lecture on this topic in July 1997. Our discussions following my lecture lasted for four hours spread over three days. Don Page has had an excellent physics career in quantum cosmology in his own right, but he began to achieve fame as a postdoctoral fellow with Stephen Hawking. The Hawkings were not financially well off in the years prior to publication of his best selling book and needed some help to keep going. So Don Page went to live with the Hawkings for the period 1976-1979.

Page describes these years in the book (the book about the film about the book!). He said, "I would usually get up around 7:15 or 7:30 AM, take a shower, read in my Bible and pray. Then I would go down at 8:15 and get Stephen up. At breakfast, I would often tell him what I'd been reading in the Bible, hoping that maybe this would eventually have some influence. I remember telling Stephen one story about how Jesus had seen the deranged man, and how this man had these demons, and the demons asked that they be sent into a herd of swine. The swine then plunged over the edge of the cliff and into the sea. Stephen piped up and said, 'Well, the Society for the Prevention of Cruelty to Animals would not like that story, would they!'"

Page has stated, "I am a conservative Christian in the sense of pretty much taking the Bible seriously for what it says. Of course I know that certain parts are not intended to be read literally, so I am not precisely a literalist. But I try to believe in the meaning I think it is intended to have." Expressing the universal goal of theoretical physicists for simplicity in their methods, Page makes an interesting connection to the spiritual world: "If the universe basically is very simple, the theological implications of this would need to be worked out. Perhaps the mathematical simplicity of the universe is a reflection of the personal simplicity of the Gospel message, that God sent His Son Jesus Christ to bridge the gap between Himself and each of us, who have rejected God or rejected what He wants for us by rebelling against His will and disobeying Him. This is a message simple enough even to be understood by children."

My final example is Chris Isham, Professor of Theoretical Physics at Imperial College of Science and Technology, University of London. The superb popular writer and former research physicist Paul Davies has described Isham as "Britain's greatest quantum gravity expert." This is high praise indeed when one considers that Stephen Hawking's research area is quantum gravity. I had the pleasure of chatting with Professor Isham for a while when I gave this lecture at Imperial College in May 2000. Alluding to the philosopher Paul Tillich, Chris Isham states "The God of Christianity is not only 'the ground of being.' He is also Incarnate." Essential therein "is the vision of the Resurrection (of Jesus Christ) as 'the new creation out of the old order' and . . . the profound notion of the 'redemption of time' through the life and death of Jesus Christ. I think it will be rather a long time before theoretical physics has anything useful to add to that." Let me be quick to extinguish one possible interpretation of Professor Isham's last sentence. By no means is Chris Isham belittling the importance of theoretical physics. Isham has committed his entire professional life to the pursuit of theoretical physics. Isham is passionate about theoretical physics. Isham is rather saying that

what he has found in Jesus Christ surpasses anything that physics could hope to provide in terms of ultimate meaning.

VII. The Limits of Science

A statement that I think gives some balance to this discussion was made by one of my scientific heroes, Erwin Schroedinger, after whom the most important equation in science is named: the Schroedinger Equation. I have spent a good bit of my professional life trying to solve this equation for atoms and molecules. Toward the end of Schroedinger's career he began to write more expansively. His 1942 book "What is Life?" is thought to have inspired an entire generation of molecular biologists. The statement I would like to quote comes from Schroedinger's 1954 book "Nature and the Greeks." In it he takes a dim view of what we might call scientific imperialism. The Schroedinger statement in question is:

"I am very astonished that the scientific picture of the real world around me is very deficient. It gives us a lot of factual information, puts all of our experience in a magnificently consistent order, but it is ghastly silent about all and sundry that is really near to our heart, that really matters to us. It cannot tell us a word about red and blue, bitter and sweet, physical pain and physical delight; it knows nothing of beautiful and ugly, good or bad, God and eternity. Science sometimes pretends to answer questions in these domains but the answers are very often so silly that we are not inclined to take them seriously."

Although science is an inspiring pursuit in its proper domain, and a genuine delight to me and others, it is not the whole story. Jane Hawking commented on this aspect of her husband's work following the publication of "A Brief History of Time." She said "Stephen has the feelings that because everything is reduced to a rational, mathematical formula, that must be the truth. He is delving into realms that really do matter to thinking people and, in a way, that can have a very disturbing effect on people - and he's not competent."

In a similar vein my longtime friend and Berkeley faculty colleague Phillip Johnson states "The irony of the situation is that Hawking's professional life currently is devoted to telling a story about the cosmos in which the elements that make his life interesting - love, faith, courage, and even creative imagination - disappear from view. Aspiring to know the mind of God, he can imagine nothing more interesting than a set of equations governing the movement of particles. A unified field theory would be a major scientific accomplishment, of course. But to Hawking it is just a step toward a distant but attainable goal of what he calls 'a complete understanding of the events around us, and of our own existence.' The way to this goal does not seem to require reading the Bible or Shakespeare, living in a variety of cultures, experiencing art, climbing mountains, or falling in love and having children. All it involves is 'the intellectually challenging task of developing better approximation methods.'" Although Phil does not seem to appreciate the great affection with which persons such as Hawking and I hold equations, there is much that is worthy of consideration in Professor Johnson's analysis.

Richard Feynman states in his 1990 book, "The Character of Physical Law," that "Everything in physical science is a lot of protons, neutrons and electrons (parenthetical remark by HFS - and don't we love them, especially electrons!), while in daily life, we talk about men and history, or beauty and hope. Which is nearer to God - beauty and hope or the fundamental laws? To stand at either end, and to walk off that end of the pier only, hoping that out in that direction is a complete understanding, is a mistake." I would have to say that, at least in the final sentence of "A Brief History of Time," Stephen Hawking has walked off one end of Feynman's pier.

VIII. Where Do We Go from Here?

In his book "The Fingerprint of God," Hugh Ross seeks to construct a bridge between cosmology and matters of ultimate importance. With minor modifications, I wholeheartedly concur. Having presented the opinions of many others in this lecture, the following represents my own position:

1. The big bang represents an immensely powerful yet carefully controlled release of matter, energy, space, and time within the strict confines of very carefully fine-tuned physical constants and laws which govern their behavior and interactions. The power and care this explosion reveals exceed human potential for design by multiple orders of magnitude.

2. A Creator must exist. The big bang ripples (April 1992) and subsequent scientific findings are clearly pointing to an ex nihilo creation consistent with the first few verses of the book of Genesis.

3. The Creator must have awesome power and wisdom. The quantity of material and the power resources within our universe are truly immense. The information, or intricacy, manifest in any part of the universe, and (as Allan Sandage has well stated) especially in a living organism, is beyond our ability to comprehend. And what we do see is only what God has shown us within our four dimensions of space and time!

4. The Creator is loving. The simplicity, balance, order, elegance, and beauty seen throughout the creation demonstrate that God is loving rather than capricious. Further, the capacity and desire to nurture and to protect, seen in so many creatures, makes sense if their Creator possesses these same attributes. It is apparent that God cares for His creatures, for He has provided for their needs.

5. The Creator is just and requires justice. Inward reflection and outward investigation affirm that human beings have a conscience. The conscience reflects the reality of right and wrong and the necessity of obedience.

6. Each of us falls hopelessly short of the Creator's standard. We incur His displeasure when we violate any part of God's moral law in our actions, our words, and our thoughts. Who can keep his or her thoughts and attitudes pure for even an hour?

Certainly not me. If each person falls short of his or her own standards, how much more so of God's perfect standards? For many years I sought to get a "passing grade" with God by comparing myself with other sinners.

7. Because the Creator is loving, wise and powerful, He made a way to rescue us. When we come to a point of concern about our personal failings, we can begin to understand from the creation around us that God's love, wisdom, and power are sufficient to deliver us from our otherwise hopeless situation.

8. If we trust our lives totally to the Rescuer, Jesus Christ, we will be saved. The one and only path is to give up all human attempts to satisfy God's requirements and put our trust solely in Jesus Christ and in His chosen means of redemption, namely, His death on the cross.

The above outline is, of course, just an outline. To fill in the outline of this bridge over the troubled waters of human experience, the reader may turn to Chapter 8, of my book, my lecture entitled "The Ten Questions that Intellectuals Ask about Christianity." Several of these questions arise persistently during Q&A times following the present lecture on cosmology.

