Gonzaga Lecture I.

Is there a conflict between religion and science? It depends, of course, on what religion one is talking about. As a Catholic, I am most concerned, naturally, with the Catholic faith. But most of what I will say in this talk would apply equally well to the mainstream Protestantism and Judaism. So "religion" in this talk means biblical religion.

There is no conflict between religion, so understood, and science. What there is, and long has been, is a conflict between religion and materialism.

Materialism is not science, although it often wraps itself in the mantle of science and is called, even by its opponents, "scientific materialism". It is, rather, a philosophical doctrine. It is a very simple doctrine, and this simplicity accounts for much of its appeal. It says that the ultimate reality is matter, and therefore everything that happens, everything that exists, can be explained by the laws of physics and blind chance.

However, there is more to scientific materialism than this. It is not just a philosophical opinion. As embraced by many people, it is a passionately held ideology that sees itself as having almost a salvific mission. That mission is to free men's minds from superstition in all its forms, but especially in the form of religion.

Religion thus plays for some materialists the role of a needed enemy, the struggle against which contributes to the larger meaning and purpose of their lives. It is necessary to their world view, therefore, that there be a conflict between science and religion.

There are three elements in this supposed conflict. First, it is claimed that religious people and religious institutions have historically been hostile to science. Here, the trial of Galileo is often invoked. Second, it is claimed that, whatever the personal

attitudes of religious people, whether hostile to science or not, there is an inherent incompatibility between the religious and scientific views of the world. Science is based on natural explanations of phenomena, while religion, they say, is based on the supernatural. Science is based on reason, while religion is based on dogma, faith, and mystery, which are seen as inimical to reason. Third, it is claimed that the actual discoveries of science since the time of Copernicus have given us a picture of the world that ever more diverges from the picture that religion painted of it. In other words, materialism has a standard interpretation of the history of scientific discovery as debunking religion. I will call this materialism's "Story of Science".

Let us begin with the first claim, that religious people and institutions have historically been hostile to science. A standard account of scientific history has it that after the great achievements of the ancients, especially the Greeks, the rise of Christianity snuffed out the further development of science and mathematics for over a thousand years. The Christians, it is said, were so obsessed with the next world that they had no interest in understanding this one. It was the supernatural, not the natural, which interested them. Since natural science did not contribute to salvation, they did not pursue it. Supposedly, science did not come to life again until the West began to throw off the shackles of religion in the Renaissance. When science did begin to revive, it was immediately attacked by the Church, as we are supposed to see from the condemnation of Galileo. The emancipation from religion and the consequent development of a scientific outlook accelerated during the Enlightenment. The decisive battle came with Darwin, a battle that is still being fought in the schools and the courts.

The foregoing is a very common view of scientific history, but it is extremely distorted.

The first thing to realize is that Christianity and Judaism were not based on supernaturalism, in the sense of a rejection of a natural order. Indeed, scholars tell us that the Book of Genesis was a polemic against pagan supernaturalism and superstition. When Genesis said that the Sun and Moon were lamps placed by God in the heavens to light the day and night, it was attacking the pagan religions that

worshipped the Sun and Moon. When it said that man, was made in the image of God, and was to exercise "dominion" over the animals, Genesis was attacking the paganism in which men worshipped and bowed down to animals or to gods made in the image of animals.

Whereas in paganism, the world was imbued with supernatural and occult forces, and populated by myriads of deities, gods of war, gods of the ocean and of the earth, goddesses of sex and fertility, and so forth, Jews and Christians taught that there was only one God who was to be sought not **within** Nature, not within its phenomena and forces, but outside of Nature, a God who was indeed the Author of Nature. In this way, biblical religion desacralized and depersonalized the world. To use Weber's term, it "dis-enchanted" the world. It made the world, indeed, into a natural world, and thus cleared the ground and prepared the soil for the (much) later emergence of science.

The biblical religions, then, taught that there was a natural order, which came from God. It was this very orderliness of the universe that pointed to its creator. The Latin Christian writer Minucius Felix, writing in the second century, had this to say:

> "If upon entering some home you saw that everything there was well-tended, neat, and decorative, you would believe that some master was in charge of it, and that he was himself much superior to those good things. So too in the home of this world, when you see providence, order, and law in the heavens and on earth, believe that there is a Lord and Author of the universe, more beautiful than the stars themselves and the various parts of the whole world."

Note that he does not point to the miraculous, but to the providence, order, and law in the universe as evidence of God. The classic Jewish and Christian argument was that if there is a law there must be a Lawgiver. Of course, God was the Lawgiver to Israel --- the first Books of the Bible are called the Torah, or Law --- but He is the Lawgiver also to the cosmos itself. The Lord says through the prophet Jeremiah, "When I have no covenant with day and night, and have given no laws to heaven and earth, then too will I reject the descendants of Jacob and of

my servant David." Psalm 148 tells of the Sun, the Moon, the stars, and the heavens obeying a divinely given "law that will not pass away." The ancient rabbis said, "The Holy One, blessed be he, consulted the Torah when he created the world." The Torah was thus a law that existed eternally in the mind of God and according to which the universe was made.

In the eleventh century, when Western Europe began to emerge from the darkness brought on by the barbarian invasions, it became aware of the great achievements in science of the ancient Greeks. This awareness engendered an insatiable curiosity about and demand for the works of ancient Greek scholars, and led in turn to a veritable frenzy of translation of their works into Latin, either from Arabic versions obtained in Spain, or directly from Greek versions obtained from the Byzantines. In those days what we call natural science was called "natural philosophy" --- indeed it was called that well into the modern era --- and the mediaeval universities were founded largely as places where this new knowledge could be studied. This interest in Greek natural philosophy was shared by the theologians and the clergy. Indeed, in mediaeval universities the study of natural philosophy was a prerequisite for the study of theology.

What occurred in the founding of the mediaeval universities was --for the first time in human history -- the "institutionalizing" of science. This has been emphasized by the respected historian of medieval science, Edward Grant. Previously, science had depended upon the patronage of wealthy or powerful individuals who happened to have a personal interest in it, and was therefore a hit or miss affair, subject to the vicissitudes of politics and economics. However, in the mediaeval universities --- which were sponsored by and protected by the Church --- for the first time a permanent, stable community of scholars was created that studied scientific questions continuously from generation to generation, i.e. a scientific community came into being.

Without this scholarly community, the Scientific Revolution would not have had the soil in which to germinate.

We see, then, that the Church was not hostile to a naturalistic understanding of

universe. Indeed, according to Edward Grant, it became a commonplace as early as the twelfth century for philosophers and theologians to refer to the universe as a *machina*, a "machine".

When Galileo was forced to recant it was not because the Church was upholding a supernaturalistic view of the universe. On the contrary, the Aristotelian-Ptolemaic theory of astronomy that the Church had favored was just as naturalistic as the Copernican theory that it condemned. The condemnation of Galileo was a terrible blunder, but it was not a rejection of science. This is shown by the words of Cardinal Bellarmine himself, the head of the Roman Inquisition during what is sometimes called Galileo's "first trial". Bellarmine said, "If it were demonstrated that [the Sun were really motionless and the Earth in motion] we should have to proceed with caution in interpreting passages of Scripture that appear to teach the contrary, and rather admit that we do not understand them than declare something false which has been proven to be true." However, Bellarmine went on to say that he had "grave doubts" that such a proof existed and that "in case of doubt" one must stay with the traditional interpretation of those passages of Scripture. It should be noted that, as a matter of fact, a genuine proof that the Earth moves was not available in Galileo's time. There were hints and evidence that pointed in that direction, but nothing really conclusive.

The Galileo case was very much an aberration. The Church has always had a favorable attitude toward science. One fact that shows this very clearly is the large number of priests who made significant contributions to science all the way from the thirteenth century to the twentieth. Let me list a few noteworthy examples.

In the Middle Ages, we find such figures as St. Albert the Great, who did original work of observation and classification in botany and zoology; Robert Grosseteste, bishop of Lincoln, who studied the refraction of light; Thomas Bradwardine, archbishop of Canterbury, one of the first people to write down an equation for a physical process; and Nicholas of Oresme, bishop of Lisieux, who made significant contributions to both mathematics and physics. He discovered how to combine exponents. He was the first person to graph a mathematical function. He showed that the apparent daily motion of the Sun could be satisfactorily explained

by the rotation of the Earth on its axis.

The first important figure in the Scientific Revolution was Copernicus, who, though probably never ordained, was an ecclesiastic, namely a canon of Frauenberg Cathedral.

The Scientific Revolution really exploded in the 1600's, and there we find the Catholic clergy, especially the Jesuits, in the forefront of research. Fr. Christoph Scheiner discovered sunspots independently of Galileo and made the most detailed studies of them. Fr. Francesco Grimaldi made important discoveries in optics, including the phenomena of the diffraction of light and the destructive interference of light. Fr. Giovanni Riccioli discovered the first "binary" or double star.

Fr. Marin Mersenne is a well known figure in the history of mathematics. But he also did important research in science. He has been called the father of acoustics. Fr. Francesco Cavalieri made important contributions to the development of Calculus.

One of the leading biologists in the world in the 1700s was Fr. Lazzaro Spallanzani. Fr. Rene-Just Haüy who was active around the time of the French Revolution, is called the father of crystallography. Fr. Giuseppe Piazzi, head of the Palermo Observatory, discovered the first known asteroid in 1801. One of the founders of modern astrophysics, the man who developed the spectral classification of stars that is still used today, was Fr. Angelo Secchi, who died in 1878. Fr. Bernhard Bolzano did groundbreaking work in mathematics in the early decades of the 19th century. The Bolzano-Weierstrass theorem and the Bolzano function are named after him. The father of genetics was the Austrian monk, Gregor Mendel, who died in 1884. One of the two originators of the Big Bang theory was the Belgian priest and physicist Georges Lemaitre, who died in 1966. Fr. Julius Nieuwland made breakthroughs that led to the first synthetic rubber, neoprene.

Obviously, had the Church been hostile to science there would not have been so many distinguished priest-scientists over a period spanning eight hundred years.

But what, it will be asked, of Darwin? Didn't the Church attack him? Not at all. The Catholic Church never condemned or even expressed any kind of disapproval of evolution. To anyone who might doubt this, I suggest looking at the article on "evolution" in the old Catholic Encyclopedia, which now can be read online. This article, published in 1909 (with of course a *nihil obstat* and *imprimatur*), said, after explaining evolutionary theory as it then stood, "This is the gist of the theory of evolution as a scientific hypothesis. It is in perfect agreement with the Christian conception of the universe." The first official pronouncement by the Catholic Church on evolution did not come until 1950, when Pope Pius XII, in the encyclical *Humani Generis,* taught that there was nothing in evolution as a biological theory that was contrary to the Catholic faith.

So much for the idea that religion has been an enemy of science.

But what of the question whether science has been an enemy of religion? Certainly that was not the view of most of the great founders of modern science who were themselves religious, men such as Copernicus, Kepler, Galileo, Newton, Lavoisier, Ampere, Faraday, Maxwell, and Kelvin. Indeed, most scientists were religious believers up to at least the middle of the nineteenth century. And today a large proportion of scientists remain religious.

However, as I mentioned earlier, one of the main claims of scientific materialists is that the **actual discoveries** of science over the last four hundred years have rendered the religious conception of the world incredible. If all those great founders of modern science were religious, they say, it is only because they did not recognize the implications of their own discoveries. For according to scientific materialists virtually every great advance in science has served in some way to debunk religious beliefs. This interpretation or version of scientific history is what I called the materialist's "Story of Science". In the remainder of this talk I would like to examine this story critically. It has five major themes.

The first theme is the overturning of the religious cosmology --- what one might

call the Copernican theme. We now know that we do not live at the center of a cozy little cosmos, but in what Bertrand Russell called a "backwater" of a vast universe. The Earth is but a tiny planet orbiting an insignificant star, near the edge of an ordinary galaxy that contains a hundred billion other stars, in a universe with more than a hundred billion other galaxies.

The second theme is the overthrow of design. Religious believers saw God's handiwork all around them in the world. Whether it was the starry heavens or the beauties of living things, they saw the magnificent productions of Nature as having been fashioned by the hand of God. Science, however, showed that they were the result of mechanisms that depended upon a combination of impersonal laws and blind chance. Genesis spoke of God placing the Sun and Moon in the firmament. Astrophysics shows us instead that they condensed from swirling clouds of gas and dust under the attraction of gravitational forces. Darwin showed how the intricate structures of living things could arise from natural selection operating upon random mutations. When Napoleon asked Laplace why God never was mentioned in his treatise on celestial mechanics, Laplace famously replied that he "had no need of that hypothesis." The laws of physics and the laws of probability had taken the place of God.

These first two themes blend together to give the third theme of the materialist's story, what the late Stephen Jay Gould called "the dethronement of man". With the Earth but an infinitesimal speck of flotsam in the limitless ocean of space, and the human race but a chemical accident, we can no longer believe ourselves, so it is said, to be the uniquely important beings for whom the universe was created. Indeed, not only was mankind not the purpose toward which Nature was directed, but Nature had no purpose. Modern physics has banished teleology.

The fourth theme, which goes back to Newton, is the discovery of physical determinism. The laws of Nature were discovered to form a closed and complete system of cause and effect. Every event could be understood as arising inevitably from the past state of the universe in a way that is precisely determined by the mathematical laws of physics. As Laplace said at the beginning of the nineteenth century, if the state of the world were completely known at one instant of time, its

whole future development could in principle be calculated down to the minutest detail. If this were true, it would raise serious difficulties for the Jewish and Christian doctrine of free will. For even if we had wills that were free, it would seem that they could have had no effect upon the world of matter, including our own bodily organs. They could not affect, in particular, what we say or do.

This leads to the fifth and final theme of the materialist's story, the emergence of a completely mechanistic view of man himself. Already in the seventeenth century the possibility was widely discussed that animals could be understood as machines or automata. The more radical thinkers of the Enlightenment, like La Mettrie and Baron d'Holbach, extended this view to human beings. Now, with the processes of life understood in terms of chemistry, and the brain understood to be a complex biochemical computer, the triumph of this mechanistic view of man seems virtually complete.

The story that I have just outlined should not be lightly dismissed. There are many people, not all of them hostile to religion, who find this interpretation of scientific history not only plausible but compelling. And it must be admitted that, in part, this is because much in scientific history up through the nineteenth century lent itself to this interpretation, or seemed to. And the startling developments in physics in the twentieth century only reinforced this view of things. People saw dramatic discoveries, like Einstein's theory of relativity and quantum theory, as demonstrating once again that all traditional or familiar or intuitively obvious notions are naïve and fated to be cast aside. Science as debunker, it seemed, was continuing on its relentless course.

However, this view of twentieth-century science is misleading. It is true that science debunked many ideas in the twentieth century, but what it chiefly debunked, I will now argue, was the materialist's old Story of Science. This was not fully appreciated, because people saw what they expected to see. They extrapolated from the past story line. But the discoveries of the twentieth century threw some twists into the plot. Those twists have, in my view, invalidated, or at least called into serious question, every lesson that the materialist wished us to draw from scientific history.

What are those twentieth-century plot-twists? I will talk about five of them, which correspond rather closely to the five themes of the materialist's Story of Science.

The first theme of that story, you will recall, was the Copernican theme --- the overturning of the religious cosmology. Supposedly, biblical religion taught that man was at the center of the universe. Now, this is certainly a gross oversimplification, to the extent that it is true at all. The idea that space has a geometrical center entered Western thought, not from the Bible, but from pagan Greek science, specifically from Aristotle and Ptolemy. There was, however, one point of cosmology that biblical religion did introduce and insist upon, and which has radically distinguished it from the beliefs of pagans and materialists. That point was not about space and whether it has a center, but about time and whether it had a beginning.

The ancient pagan philosophers, for the most part, believed in an eternal universe. Plato, for instance, wrote, "Matter exists. Nothing can come from nothing; hence matter is eternal. We cannot admit the creation of matter." Aristotle, too, believed in the eternity of the world. Modern atheists have generally followed the ancient pagans in this regard. It was the Bible --- indeed the very first words of the Bible --- that introduced the idea of a Beginning. That the universe had a beginning in time was explicitly taught as an article of Christian faith by both the Fourth Lateran Council in 1215 and the First Vatican Council in 1870, both of which spoke of God creating the world "from the beginning of time", "*ab initio temporis*".

Up until the end of the nineteenth century, it seemed that scientific discoveries were vindicating the pagan and materialist view. In Newtonian physics it was natural to assume that the time coordinate, like the space coordinates, stretched in an unbroken line from minus infinity to plus infinity. The discovery of the law of conservation of energy --- the First Law of Thermodynamics --- gave further support to the eternity of the world, for it said that energy could neither be created nor destroyed. Chemists discovered that the quantity of matter, as measured by its mass, was also conserved. We find the eminent chemist, Svante Arrhenius, saying in 1911: "The opinion that something can come from nothing is at variance with

the present-day state of science, according to which matter is immutable." Thus every scientific indication at the end of the nineteenth century was that space, time, matter, and energy had always existed and always would. There was no hint of a Beginning.

The first intimation that time could have a beginning came with Einstein's theory of General Relativity in 1916. In the 1920s Alexander Friedmann, a Russian mathematician, and Georges Lemaitre, a Belgian priest and physicist, independently proposed models of the universe based on Einstein's theory in which it was expanding from some initial explosion, which Lemaitre called "the primeval atom" and which is now called the Big Bang. In 1929, the astronomers Hubble and Humason, following up on earlier work of Slipher, announced their discovery that the cosmos is expanding. There was much skepticism about the Big Bang theory, much of it for scientific reasons, but some clearly resulting from materialist prejudice. The physicist Walter Nernst declared, "To deny the infinite duration of time would be to betray the very foundations of science." As late as 1959, thirty years after Hubble and Humason's results, a survey showed that most American astronomers and physicists still believed in a universe with no beginning. Powerful confirmation of the Big Bang theory came with the discovery in the late 1960s of the so-called cosmic microwave background radiation by Penzias and Wilson, for which they were awarded the Nobel Prize.

I heard an interesting story just recently from a colleague of mine who is an astrophysicist. He was present at the historic scientific conference in Washington D.C. where the results of satellite observations were announced that conclusively confirmed the Big Bang theory. The chairman of the session was an astrophysicist named Geoffrey Burbidge, who was a well-known holdout against the Big Bang theory. After the lecture explaining the new discovery, which was followed by thunderous applause, Burbidge went to the podium and said simply: "Well, I guess the Bible was right, after all. Any questions?"

Over the decades, there have been many attempts to salvage the idea of an eternal universe. Einstein himself, when he first realized that his theory tended to lead to an expanding (or contracting) universe, attempted to modify it in such a way as to

allow the universe to be static. Later, after the discovery that the universe was **indeed** expanding, an idea called the Steady State Theory was proposed, by Fred Hoyle and others, according to which the universe has been expanding from all eternity, without a Big Bang. Another idea is that the universe has been expanding and contracting cyclically for ever --- the so-called bouncing universe.

These ideas are no longer regarded as viable, at least in their original forms. However, there are more recent attempts to reinstate an eternal universe, such as the eternal inflation idea of Andrei Linde and the cyclic universe idea of Steinhardt and his collaborators. All of these ideas have serious difficulties, which I cannot describe here. In fact, very recently, the physicists Alan Guth and Alexander Vilenkin have proven a theorem that makes it appear even more difficult to construct a theory of an eternal universe than had been supposed.

We cannot at this stage be absolutely certain that the universe had a beginning; however, we can say that given the present state of theory and observation, it seems highly probable that it did.

The second theme of the materialist's Story was the overthrow of design. The will of God had been replaced as an explanation by impersonal laws and blind chance. This represented a shift in perspective. Whereas it had once been argued, as we have seen, that the lawfulness of Nature required a Lawgiver, now it was argued that the laws of nature constituted in themselves, and by themselves, a sufficient explanation of reality. This brings us to the second plot twist in the story of science. In the twentieth century another shift in perspective took place. One might call it the aesthetic turn. This requires some explanation.

Physics begins with phenomena that can be observed with the senses, perhaps aided by simple instruments, like telescopes. It finds regularities in those phenomena and seeks mathematical rules that accurately describe them. Physicists call such rules empirical formulas or phenomenological laws. At a later stage, these rules are found to follow from some deeper and more general laws, which usually require more abstract and abstruse mathematics to express them. Underlying these, in turn, are found yet more fundamental laws. As this deepening

has occurred, two things have happened. First, there has been an increasing unification of physics. Whereas, in the early days of science, Nature seemed to be a potpourri of many kinds of phenomena with little apparent relation, such as heat, sound, magnetism, and gravity, it later became clear that there were deep connections. This trend toward unification accelerated throughout the twentieth century, until we now have begun to discern that the laws of physics make up a single harmonious mathematical system.

Second, physicists began to look not only at the surface physical effects, but increasingly at the form of the deep laws that underlie them. They began to notice that those laws exhibit a great richness and profundity of mathematical structure, and that they are indeed, remarkably beautiful and elegant from the mathematical point of view. As time went on, the search for new theories became guided not only by detailed fitting of experimental data, but by aesthetic criteria. In fact, just a few months ago a new book came out entitled *It Must Be Beautiful: Great Equations of Modern Science*.
One of the best-selling books on science in recent years is entitled *The Elegant Universe*. A classic example of aesthetic criteria guiding research was the discovery of the Dirac Equation in 1928. Paul Dirac was looking for an equation to describe electrons that was consistent with both relativity and quantum theory. He hit upon a piece of mathematics that struck him as "pretty". "[It] was a pretty mathematical result," he said, "I was quite excited over it. It seemed that it must be of some importance." This led him to what has been justly described as among the highest achievements of twentieth century science.

The same quest for mathematical beauty dominates the search for fundamental theories today. One of the leading theoretical particle physicists in the world today, Edward Witten, trying to explain to a skeptical science reporter why he believed in superstring theory in spite of the dearth of experimental evidence for it, said, "I don't think I've succeeded in conveying to you its wonder, incredible consistency, remarkable elegance, and beauty."

All of this has changed the context in which we think about design in nature. When the questions physicists asked were simply about particular sensible phenomena,

like stars, rainbows, or crystals, it may have seemed out of place to talk about them, however beautiful they were, as being fashioned by the hand of God. They could be accounted for satisfactorily by the laws of physics. But now when it is the laws of physics themselves that are the object of curiosity and aesthetic appreciation, and when it has been found that they form a single magnificent edifice of great subtlety, harmony and beauty, the question of a cosmic designer seems no longer irrelevant, as it did to some, but inescapable.

In 1931, Hermann Weyl, one of the great mathematicians and mathematical physicists of the twentieth century, gave a lecture at Yale University in which he said the following:

> "Many people think that modern science is far removed from God. I find, on the contrary, that it is much more difficult today for the knowing person to approach God from history, from the spiritual side of the world, and from morals; for there we encounter the suffering and evil in the world, which it is difficult to bring into harmony with an all-merciful and almighty God. In this domain we have evidently not yet succeeded in raising the veil with which our human nature covers the essence of things. But in our knowledge of physical nature we have penetrated so far that we can obtain a vision of the flawless harmony which is conformity with sublime reason."

The third theme of the materialist's story was the "dethronement of man." A classic statement of this view was given by Steven Weinberg in his book *The First Three Minutes.* He wrote:

> "It is almost irresistible for humans to believe that we have some special relation to the universe, that human life is not just a farcical outcome of a chain of accidents, … but that we were somehow built in from the beginning. … It is very hard for us to realize that [the entire earth] is just a tiny part of an overwhelmingly hostile universe. … The more the universe seems comprehensible, the more it also seems pointless."

Certainly, given the immensity of the universe and the impact of Darwinian ideas,

it is easy to understand why this sentiment is widespread. However, in the last few decades there has been a development that suggests a very different estimate of man's place in the universe. This plot twist was not a single discovery, but the noticing of many facts about the laws of nature that all seem to point in the same direction. These facts are sometimes called "anthropic coincidences".

The term "anthropic coincidence" refers to some feature of the laws of physics that seems to be just what is needed for life to be able to evolve. In other words, it is a feature whose lack or minute alteration would have rendered the universe sterile. Some of these features have been known for a long time. For example, William Paley, already in 1802, in his treatise *Natural Theology,* pointed out that if the law of gravity had not been a so-called "inverse square law" then the Earth and other planets would not be able to remain in stable orbits around the Sun. Another example pointed out a long time ago is that water's remarkable, indeed almost unique, property of expanding when it freezes, which causes ice to float instead of sink, prevented lakes and rivers from freezing solid in winter with devastating consequences for life.

Perhaps the most famous anthropic coincidence was discovered in the 1950s, when it was found that except for a certain very precise relationship satisfied by the energy levels of the Carbon-12 nucleus most of the chemical elements in Nature would have occurred in only very minute quantities, greatly dimming the prospects for life.

Another well-known example concerns the strength of the so-called strong force. This is one of the four basic forces of nature, and is responsible for holding atomic nuclei together. If the strong force were a few percent weaker than it is, a certain critical atomic nucleus called the deuteron would not have been able to hold together, and in consequence the whole process by which the different elements are synthesized in the Big Bang and in stars would have been fatally disrupted. On the other hand, had the strong force been a few percent stronger, stars like the Sun would have burned up their fuel so rapidly that life on their planets would not have had time to evolve.

The strong force seems fine-tuned to make life possible.

Interest in and attention to such anthropic coincidences has greatly intensified since the work of the astrophysicist Brandon Carter in the 1970s. Many of these coincidences, especially in physics, have now been identified. The most natural interpretation of them is that we were indeed "built in from the beginning", in Steven
Weinberg's phrase, and that the universe, far from being "overwhelmingly hostile" to us, as he asserted, is actually amazingly, gratuitously hospitable.

Many leading scientists have taken an interest in anthropic coincidences, for instance Steven Weinberg himself, Andrei Linde,
Andrei Sakharov, Lev Okun, Martin Rees, Alexander Vilenkin, John Barrow, and Stephen Hawking. It may seem strange, but many of these men (though not all of them) are atheists, and do not see in the anthropic coincidences any evidence for God. How then do they account for these coincidences? Really, there is only one way to account for them in a purely naturalistic way, namely by a hypothesis called (misleadingly) the "Anthropic Principle".

What is the Anthropic Principle? There are various versions, but the one taken most seriously is what is sometimes called the weak anthropic principle. It is not really a principle at all, but simply the idea that a variety of different laws of physics apply in different regions of the universe, or even in different universes, and that so many possible laws of physics are sampled in this way that there is really no coincidence involved in the fact that in some places the laws are "just right" for life to emerge.

An analogy will help make the idea clearer. The conditions on earth are in many ways well suited for life. Earth is not too hot or too cold. Its surface gravity is enough to maintain an atmosphere, but not **too** strong. It has a large moon that stabilizes its rotation on its axis, leading to regular and moderate seasonal cycles. There are many such aspects of conditions on earth that seem strangely fortuitous for life. However, there is a simple way to explain this in a natural way. There are, almost certainly, tens of billions of planets in our galaxy alone, and hundreds of

billions of such galaxies. These 10 thousand billion billion (or so) planets come in a vast spectrum of sizes, temperatures, chemical compositions, and so on. Some are too hot for life, some too cold, some too large, some too small. But it is hardly surprising, given their vast number, that some are "just right". One could call this the Goldilocks idea. The idea of the Anthropic Principle is simply that there may be many **universes** --- or at least **domains** in our universe --- where the very laws of nature are effectively different; and some of these universes or domains are bound to have laws that are "just right" for life.

Can this idea explain the anthropic coincidences? It certainly has the potential of explaining some of them. However, it seems implausible that it would explain all of them. For it to do so, one would have to suppose that the universe was made up of distinct domains in which the effective laws of physics were of a fantastically rich variety, and this seems unlikely. Moreover, even if it were the case, a universe of such singular richness and potentiality would itself seem to point to a designer.

Nevertheless, the Anthropic Principle idea is a speculative hypothesis that might allow one to explain at least **some** of the anthropic coincidences in a purely naturalistic way, **without** invoking "intelligent design" or God. You would think, therefore, that it would be a very popular idea among scientists of atheist leanings. Remarkably, however, it is not. Indeed, the Anthropic Principle idea is looked upon with great suspicion, and even hostility by most scientists, **especially** those who are atheists.

This is illustrated by something that was said at a recent physics conference held at Case Western Reserve University, and reported in the New York Times a few months ago. At this conference, there was a panel discussion of the subject of the Anthropic Principle". Explaining his aversion to the idea, the eminent particle physicist David Gross (a man I know and like and whose intellectual gifts I deeply respect) said that his opposition was at bottom "totally emotional". The whole subject, he felt, was "dangerous" because it "smells like religion and intelligent design."

The point is that many atheists are so disturbed by any discussion of the anthropic

coincidences, with their potentially religious implications, that they do even want to discuss the only available idea **for explaining them away naturalistically**! As Gross is smart enough to realize, and honest enough to admit, this reaction is non-rational --- "totally emotional".

While not embraced by most atheists, the Anthropic Coincidence idea must be taken seriously. And therefore one cannot say at the present time that the anthropic coincidences point **unambiguously** toward a cosmic purpose that includes life. Yet one can say that they vitiate the materialist's claim that science has shown life and man to be mere accidents. If anything, the *prima facie* evidence is in favor of the biblical idea that the universe was made with life and man in mind.

The fourth theme of the materialist's story was the determinism of physical law. Everything in the history of physics up until the last century seemed to support this idea. All the laws discovered --- those of mechanics, gravity, and electromagnetism --- were deterministic in character. If anything seemed securely established it was physical determinism. However, in the 1920s the ground rumbled beneath the feet of physicists. Determinism was swept away in the quantum revolution. According to the principles of quantum theory, even complete information about the state of a physical system at one time does not determine its future behavior, except in a probabilistic sense.

This was terribly shocking to physicists. Indeed, one of the hallmarks of an exact science is its ability to predict outcomes. So shocking was this twist in the plot that several of the makers of the quantum revolution, including de Broglie, Einstein, and Schrodinger, were reluctant to accept this aspect of it. Einstein was never reconciled to the loss of determinism. "I do not believe", he said, "in a dice-playing God, but in perfect laws." There have been many attempts to restore determinism to physics by modifying, reformulating, or reinterpreting quantum theory in some way. None of these attempts has been completely convincing. So far, at any rate, it does not seem likely that the old classical determinism will be restored.

There are many who argue, nonetheless, that the indeterminacy of quantum theory

does not create an opening or a space for free will to operate. They argue that the basic building blocks of the human brain, like neurons, are too large for quantum indeterminacy to play a significant role. At this point, who can say? So little is known about the brain. What we can say is that there was for a long time a strong argument from the fundamental character of physical law against the possibility of free will, and this argument can no longer be so simply made. To quote Hermann Weyl again, from the same 1931 lecture:

> "We may say that there exists a world, causally closed and determined by precise laws, but … the new insight which modern [quantum] physics affords … opens several ways of reconciling personal freedom with natural law. It would be premature, however, to propose a definite and complete solution of the problem. … We must await the further development of science, perhaps for centuries, perhaps for thousands of years, before we can design a true and detailed picture of the interwoven texture of Matter, Life, and Soul. But the old classical determinism of Hobbes and Laplace need not oppress us longer."

We now turn to the fifth and final theme of the materialist's story, the mechanistic view of man himself. It is the final theme in more ways than one. Here the scientist debunks himself. Here all the grand intellectual adventure of science ends with the statement that there is no intellectual adventure. For the mind of man has looked into itself and seen nothing there except complex chemistry, nerve impulses, and synapses firing. That at least is what the materialist tells us that science has seen. However, the story is really not so simple. Here again the plot has twisted. Two of the greatest discoveries of the twentieth century cast considerable doubt upon, and some would say refute, the contention that the mind of man can be explained as a mere biochemical machine.

The first of these discoveries is, again, quantum theory. There are several rival philosophical "interpretations" of quantum theory.
In the traditional interpretation --- sometimes also called the "Copenhagen", "standard", or "orthodox" interpretation --- a crucial role is played by so-called "observers". Physics makes predictions about the results that will be obtained

from experiments or observations of the physical world. An "observer" is one who makes such experiments or observations, or at least **knows** their results. It has been argued that while the physical systems he observes can be adequately described by the laws of physics, the observer himself in his entirety cannot be so described. The observer himself must lie, at least in part, outside of the description of the world provided by physics. If one does not assume this, then one is led, in the framework of the traditional interpretation of quantum theory, to contradictions.

What is it about the observer that cannot be captured by a purely physical description? It is that which makes him able to play the role of observer, namely his capacity to know, i.e. his intellect.
Sir Rudolf Peierls, an eminent physicist of the last century put it this way: "The quantum mechanical description is in terms of knowledge. And knowledge requires **somebody** who knows."
He emphasized that it has to be **somebody**, not something.

This led Peierls and others to say that quantum theory is inconsistent with a materialistic view of the human mind. He put it this way: "The premise that you can describe in terms of physics the whole function of a human being … including its knowledge and its consciousness is untenable. There is still something missing." Eugene Wigner, a Nobel laureate in physics, stated flatly that materialism is not "logically consistent with present quantum mechanics".

Admittedly, the view I am describing, and which I espouse, is a highly controversial one. That is only to be expected, especially given the materialist prejudice that affects a large part of the scientific community. Moreover, the traditional interpretation of quantum theory has aspects that many find disturbing or highly implausible. Some even think (wrongly, in my opinion) that the role it assigns to observers leads to subjectivism or philosophical idealism. It is for this reason that many religious people also have rejected the traditional understanding of quantum theory. (I note, for example, that most of the reviews of my book by religious reviewers have had as their main criticism, or their only criticism, my treatment of quantum theory. Well-known Catholic thinkers who are on record as

opposing the Copenhagen interpretation of quantum theory include the late Mortimer Adler, Stanley Jaki, and Peter Hodgson, men for whom I have great respect.)

I do not have time tonight to explain the views of Peierls and Wigner further, or the various rival views. I will have more to say on this subject in my lecture tomorrow night. Here I merely want to note the very important fact that there is an argument against materialism that comes from physics itself, an argument that has been advanced and defended by some leading physicists and has never been refuted. In light of this, one cannot say that science points to a materialist viewpoint when it comes to the human mind.

The second discovery that arguably points to something nonmaterial about the human mind is a revolutionary theorem in mathematical logic proved in 1931 by the Austrian logician Kurt Gödel, one of the greatest mathematicians of modern times. Gödel's Theorem has profound implications. Among these are implications for what computers are able to do. It was recognized fairly quickly that Gödel's Theorem might have something to say about whether the human mind, at least in the way it does mathematics, is **itself** just a computer. Gödel was convinced that it is something more. Indeed he called materialism a "prejudice of our time". However he never developed in detail, at least in print, the argument against materialism based on his own theorem. That was first done by the Oxford philosopher John R. Lucas in the 1960s.

Lucas's Godelian argument was and remains highly controversial. However, it has been taken up and refined in recent years by the eminent mathematician and mathematical physicist Sir Roger Penrose.

Both Gödel's Theorem and the Lucas-Penrose argument to the effect that the human mind is not simply a computer are quite subtle. They cannot be explained in a few minutes. However I shall have more to say about them tomorrow night.

The important point for now is that there are arguments coming out physics and mathematics, and advanced by scientists and mathematicians of great stature,

arguments that have not been refuted and that claim to prove that man is more than a machine and more than a physical organism.

Where does this all leave us? After all the twists and turns of scientific history, we look around and find ourselves in very familiar surroundings. We find ourselves in a universe that seems to have had a beginning. We find it governed by laws that have a grandeur and sublimity that bespeak design. We find many indications in those laws that we were built in from the beginning. We find that physical determinism that seemed to chain free will has been overthrown. And we find that the deepest discoveries of modern physics and mathematics give hints, if not proof, that the mind of man has something about it that lies beyond the power of either physics or mathematics to describe.