

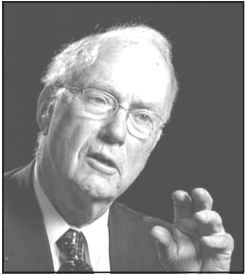


Plenary Presenters

The Convergence of Science and Religion

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Charles Townes



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Science and religion are often viewed as necessarily separate aspects of our beliefs and understanding. But I see religion as an attempt to understand the purpose of our universe and science as an attempt to understand its nature and characteristics, so that the two are necessarily closely related. The so-called anthropic principle for the physical constants and recent discoveries in cosmology such as the "Big Bang" are at least suggestive of such a relationship. We furthermore try to understand each of these fields with all our human resources: intuition, observations, logic, and esthetics, with science and religion having different emphasis on these resources yet nevertheless using all of them. Science has undergone revolutions in the past, which have rather completely changed our views, and yet science of the past has often maintained an important validity. It still faces many inconsistencies, and we must be open to new changes with deeper understanding and yet the continued validity of present science as an approximate model. Can we expect similar changes and deepening of our human understanding of religion? I discuss the parallelism and increasingly strong interaction of science and religion, which I visualize, along with the possibility of their ultimately merging into a more unified understanding of both the purpose and the nature of our universe.

First, let me try to define what we generally mean by the two words "science" and "religion." I believe we can say that science is the attempt to understand the structure of our universe and how it works—including ourselves, being part of this universe. Religion is an attempt to try to understand the meaning and purpose of this universe—including our own lives. One might of course, even ask whether there is any meaning or purpose? And, if so, what is it? If there is a meaning or purpose, this must very much affect the nature of the universe.

Science and religion have interacted over many generations, at times very strongly. Sometimes they have agreed; sometimes

they clashed. In the early days, outstanding religious leaders were often also society's best philosophers and scientific scholars. Notable clashes between science and religion have grown, however, in western civilization during the last two or three centuries as science has developed rapidly. One of these clashes occurred as a result of the development of deterministic science, involving scientific laws which it was assumed could in principle predict all subsequent events and leave no room for divine action. Another clash occurred over Darwin's evolutionary ideas, pitting creation against mere chance development. To some, these scientific developments appeared to destroy human ideas about the beauty and sacredness of our world. For example, in 1798, William Wordsworth wrote the poem, "The Tables Turned," which contains the following lines:

*Sweet is the lore which Nature brings;
Our meddling intellect
Mis-shapes the beauteous forms of things:—
We murder to dissect.*

Charles Townes, a member of the National Academy of Sciences, received the Nobel Prize for Physics in 1964 for his work in quantum electronics. He is the inventor of the maser, a device which amplifies microwaves, and co-inventor of the laser which amplifies visible light. During World War II, Townes helped develop radar bombing systems at Bell Laboratories. After the war, he joined the faculty of Columbia University, where he had the idea leading to the maser. Then, following a brief appointment as vice president of the Institute for Defense Analysis (Washington, DC), Dr. Townes became provost and professor of physics at Massachusetts Institute of Technology. Since 1967, he has been professor at the University of California (Berkeley). Charles serves on the advisory board for the ASA; he is an avid diver and enjoys snorkeling in the Bahamas.

This is an edited transcription of the presentation given Aug. 2, 2002, at the ASA Annual Meeting at Pepperdine University, Malibu, California.

Scientific ideas do sometimes appear to make mundane the real beauty of our world. On the other hand, there is another view expressed by Alexander Pope in 1732, when he wrote ("An Essay on Man," Epistle 1):

*He who through vast immensity can pierce,
See worlds on worlds compose one universe,
Observe how system into system runs,
What other planets circle other suns,
What varied beings people every star,
May tell why heaven has made us as we are.*

Astronomy has indeed on occasion elevated our thoughts and inspired religious thinking.

Science of the nineteenth century did seem in some ways to be quite inconsistent with religious thinking. Determinism was contrary to religious views and determinism seemed a very firm part of science at that time. Evolution led to the view that the creation of life, and humans, was simply a natural accident.

Parallels in Science and Religion

My own view is that how the universe is constructed and how it works, which is the scientific question, must be related to its purpose, the religious question. Furthermore, I think there is a very general similarity between science and religion which is usually not overtly recognized. This comes about in part because we humans want to try to understand, and we use all our human resources and available methods in the understanding of both religion and science. Even though we have the impression that science uses experimentation but religion does not, and we might think religion uses faith but science does not, such impressions are not realistic. Actually, science depends inherently on faith. We do not generally talk about faith in science, but rather we talk about postulates. For example, if you drop a pencil, it will fall at a particular rate. We generate physical laws that predict this will always happen. But in fact, we do not know for sure that it will do exactly the same tomorrow. We assume it will from our faith in or our postulate of the constancy of scientific laws.

Gödel provided a theorem that shows mathematically how faith is necessary in science. His theorem considers the case where to prove something we make a certain set of postulates, then we accept normal mathematical logic and use that logic to deduce things from the postulates. But Gödel proved that we can never be sure that the postulates are even self-consistent.

Einstein had a faith that the laws of gravity and the laws of electricity, magnetism, and radiation could be united. He worked on that for twenty years at least during the latter part of his life. Although he never succeeded, his devotion of twenty years working at this task represented strong faith and commitment.

What about experiments? In religious thinking we are likely to recognize the importance of observations, which are quite parallel to experimentation. Astronomy is in fact usually not like our concept of laboratory experimentation but rather it primarily involves observation. In religion we observe how people behave. What makes a wonderful person? What makes life meaningful and happy?

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Then there is intuition. We probably do not realize how frequently scientists use intuition. Often scientists think, "Well, this is the way it really ought to be." When it was discovered that light was wave-like, since known waves moved along on something like the ocean surface or a string, scientists thought there must be something throughout the universe which they called the ether and that light was a wave on that ether. People worked and worked trying to discover ether. The Michaelson-Morley experiment was such an attempt, which showed that actually there could not be anything like what had been intuitively thought to exist.

There is the intuition that the universe has always been the same. Why? Because how can anything start from nothing? The universe always seems to us to be the same now, and it presumably has always been the same. It could not have had a beginning. That idea also seems to have been wrong. We now know that there was a unique moment in the past when the universe started from something immeasurably small and it has been growing ever since. We have used and continue to use our intuition in science, and we use it in religion.

And there is revelation. One wonderful story that I always enjoy is of Auguste Kékulé the chemist, who tried hard to figure out how molecule benzene could be shaped. Kékulé kept thinking about it, and as he sat by the fireplace one night in 1866, he dreamed that he saw a snake, which coiled around and took its tail in its mouth. Suddenly he could recognize the answer, "That's it! It's a circle!"

I could say the same thing about the maser and the laser. I tried very hard to find new ways of producing radiation, other than by electronic vacuum tubes. I wanted to produce very short wavelengths, which standard techniques could not do. I worked on it for several years. One morning early I sat in a park, wondering, "Why haven't



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I been able to do this? There must be a way." Suddenly I had the idea! And out of it grew the maser and the laser. Where did that idea come from? Inspiration, or revelation if you like.

Think even of Christ. After wandering forty days in the wilderness, undoubtedly thinking over what the future might be, he came out of there knowing what to do.

Consider aesthetics. Many scientists say, "This equation is beautiful! It must be right!" In his classic poem, "Ode on a Grecian Urn," John Keats wrote: "Beauty is truth, and truth beauty." In science there is the same feeling.

What about logic and reason? Science tries very hard to use logic and reason. We try to use all our human abilities and these are important ones. The same thing is true in religion. We observe how people behave. We think about how we feel. We read the Bible and think about how people behaved in the past, and we apply our reason and logic to these observations.

Both science and religion are human understandings, and as a result they can change. Determinism was very firmly believed by scientists in the nineteenth century, but then came quantum mechanics. New science was generated. Quantum mechanics says: "Particles are not just particles but they have associated waves. Atoms behave like waves in many cases. A thing is not a particle or a wave; it's a combination." The uncertainty principle, which results from quantum mechanics, says: "We cannot precisely determine position and motion at the same time." We now recognize that this uncertainty means the future is not predictable. With such a change in our philosophy and thinking, determinism disappeared. As quantum mechanics and the lack of determinism were beginning to be understood, many scientists were puzzled. Albert Einstein himself frequently is quoted as having said: "God doesn't play dice."

Relativity has also now convinced us that there is no fixed thing in this universe. You cannot say, "The earth is going around the sun and the sun is not going around the earth." It's just convenient to say, "The earth is going around the sun," because it makes a rather simple picture. But it is equally correct in principle to say the sun goes around the earth. We no longer believe that

any point in the universe is absolutely fixed. Relativity changed all that.

Then there's the "Big Bang." We now know there was a unique moment when everything was very small. We could call it the moment of creation. Many excellent scientists have fought this position very hard, believing that there could not have been any such unique moment. But now almost all are convinced.

Dark energy is also changing our views. Apparently, the expansion of the universe is speeding up. Physicists generally attribute this to a new cosmological force, associated with "dark energy." But perhaps it is because the force of gravity is changing a bit. We are always working with postulates, and must not think that we understand it all.

Intelligent Planning and the Anthropic Principle

A general feeling that's been growing rather rapidly in the last few decades is the idea of intelligent planning. As we understand our universe more and more, we recognize it is very special. That bears on one of the basic differences between science and religion. Religion has generally taken the position that there is something very special about us as humans and about our universe. We are God's creation, especially made. Scientists frequently say, "No, it's all accidental; there's nothing special about us." However, it has become increasingly clear that we are here only because the laws of physics have certain particular values. Here are some of the things that may be associated with intelligent planning of our universe.

- The sun's intensity is very constant—lucky for us! The earth is at the right distance from the sun to provide the temperatures needed for life. The large moon encircling the earth protects us from comets. These things could, in fact, just be happy accidents, because there are billions of stars in our galaxy and there are billions of galaxies. So, while many stars and planets are unsuitable for life, even a small fraction could allow a number of sources for life, and many scientists believe there are many stars supporting life in our universe. This may be true, even though the probability for any sin-

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gle one is relatively small, perhaps as is the probability for the initiation of life.

- Assuming a suitable star and planet, what is the probability that life can form? If indeed it is a random process of molecules coming together in just the right way, the probability is very small. I have made a rough calculation, assuming about thirty amino acids must come together accidentally in just the right way. This seems likely a minimum number in order for self-replicating life to form. If we assume the whole earth is covered with a layer three feet thick of miscellaneous amino acids, it would take approximately 10 to 20 billion years for the right combination to accidentally come together, so the probability of such accidental formation of life is small. Perhaps there are special molecular forces that tend to favor the molecules assembling in a particular way, which would increase the probability of life formation—another possible aspect of intelligent planning.
- That our sun, or any star, can be such a constant source of energy for so long is hardly an accident. The properties of nuclear reaction and gravitation must be just right. Nuclear reactions must take place to provide the sun's energy, but if they are too abundant the sun would expand and blow-up—as many stars do, particularly the very old stars. If gravity were a little too strong, the sun could also be unstable. The laws of physics need to be carefully balanced.
- For the approximately one hundred different chemical elements we have on earth to be here, in particular for the important elements carbon and oxygen to exist, the electrical and nuclear forces must be just right and balanced. Fred Hoyle, who discovered how carbon and oxygen could be formed by nuclear processes within stars, was much impressed. Although he was something of a religious skeptic, Hoyle wrote in the Caltech alumni journal:

Some super-calculating intellect must have designed the properties of the carbon atom. ... A common sense interpretation of the facts suggests that some super-intellect has monkeyed with physics ... the facts seem to me so overwhelming as to put this conclusion almost beyond question.

Many scientists now recognize that indeed we and our universe are quite special. The only way we can see to avoid the idea of intelligent planning is that there may be a very large, almost infinite, number of universes, each with its own characteristics and physical laws, and of course life began in one which had just the right characteristics. There are some problems however, with such a postulate. One is that we do not know why or how the physical laws should vary randomly from one universe to another. Another is that we know of no way in which we can detect the existence of these multiple universes. It is essentially a postulate, which cannot be clearly tested and hence is not normal science.

Intelligent planning of the universe and human life still leaves plenty of problems with our present understanding. We do not see any way in which God can now intervene in our universe, as is assumed by a religious view. Quantum mechanics introduced uncertainty, so that our lives are not completely deterministic. However, experimental tests of what is known as Bell's principle seems to show that there can be no unknown force which intervenes and determines what happens. This appears to prove that there is no room for divine action.

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Present science also seems to say there is no way we can have free will. Even though an individual's future is not completely determined by physical laws according to the uncertainly principle, whatever happens is only a matter of his or her past make-up, and the random choice of quantum mechanics. Some theologians postulate that this problem is solved by "emergence." If we put together a system of atoms, we can see crystals and other complex structures emerging. The postulate is that somehow free will similarly emerges out of complexity. However, this would be contrary to our present idea of the characteristics of atoms—they can perhaps produce surprising results, but none that contradict their own properties. So while science says we do not have free will, I do not know any scientist that does not think he or she has *some* free will and can make choices.

What is consciousness? Nobody can really define a conscious being. One scientist friend of mine says "a conscious being is one that has purpose, can sense the world around it, and can take action in accordance with what it senses." To me, this sounds like a mousetrap must be considered a conscious being. We have trouble with this concept.

Science is fantastically successful at some things, but there are other things that we do not understand. Zero point fluctuations are an example. Quantum mechanics seems to be remarkable successful, but it predicts a very large amount of radiation energy throughout the universe, which is normally undetectable, but which should give our universe a very large energy density and a large expansionary force. We seem to have evidence that these



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are not present. The problem is simply set aside for the present because in so many other respects quantum mechanical predictions are remarkably correct. Another problem is that gravitational theory and quantum mechanics appear to be inconsistent, yet we accept both. Still another is that most of the matter in the universe appears to be "dark matter," that is, matter we cannot detect and cannot identify. Then there is the Higgs particle. Present theory says this particle must exist, but it has not yet been detected in spite of many tries. Some are beginning to think that perhaps it does not really exist.

In science we continue to recognize inconsistencies and to discover new laws, some of which revolutionize our conceptions. However, those things we have previously tested and thought correct are often still useful. Consider Newton's laws for particle motion and the resulting determinism. In principle, quantum mechanics has revolutionized our view and shown these ideas were not correct. Nevertheless, we still teach Newton's mechanics as part of physics. It is an excellent approximation for large objects and we use it widely. Our views have changed, but the old ideas are still useful. They both served and continue to serve good purposes. We should expect that, if our understanding of the religious aspects of life and our world improve, our views may well change. But at the same time, present ideas may be good and useful approximations. Thus, as in science, our religious ideas cannot be expected to be completely correct; we must not be hesitant to try to advance our religious understanding and even somewhat change our outlook.

Summary

In science and in religion, we use all our human abilities to understand—faith or postulate; experiments or observations, intuition, revelation, esthetics; and logic or reason. Furthermore, things we understand about science, or how the universe works, may well shed light on its purpose. Recent discoveries in cosmology and in quantum mechanics are interesting not only to scientists, but also to philosophers and theologians, and are bringing the thoughts of all these into healthy interaction.

Recognizing that there are many aspects of science as well as religion that we do not understand, that there are inconsistencies within science as well as between science and religion, and that we have no absolute proofs in science or in religion, what kind of position can we take? I believe it important to use all our human gifts and powers to understand as well as we can, to make decisions on what we conclude and believe is mostly likely correct, and then act firmly and with faith on these, our best conclusions. As we study more, we will find out more, and I believe science and religion will come increasingly closer together. *

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