

cal thinking. In a recent semester, three students told me they were planning to become ministers, and they appreciated the opportunity to develop critical-thinking skills. One of these students told me that elders in his church warned him to avoid science classes because they would be a waste of time and would not help him become a better minister. How much clearer does the need have to be before we do something about it?

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The debate about the teaching of evolution in public schools is unique to the US among Western countries.¹ Murray Peshkin's admonition to the scientific establishment to engage in mature discussions of the issues involved must be taken seriously. But such endeavors need careful preparation.

First, several facts should be taken into account explicitly. Most religions are focused on the human being, with the universe—prime target of the physicist's professional dedication—relegated to playing a supporting role. In religion, spatial and temporal dimensions are those familiar to human experience, information about the universe is that which can be acquired through our senses, and relevant causal interconnections between events are those whose consequences directly affect us. It is then quite natural that phenomena extending over a few hundred human lifetimes and images like the Earth orbiting around the Sun—which we never actually *see* happening—were met with resistance for a long time. Even today, the scientifically uninformed public has little comprehension of astronomical and geological scales; everything that invokes them is perceived as “just a theory.” The same applies to the fact that order can emerge out of chaos and purposeful behavior out of random events without any outside intervention except for some available energy and the action of a few universal physical laws. Scientifically uninformed people sense, based on subjective experience, that purposeful complexity cannot just emerge but must be designed—without being aware that self-organization occurs in so many everyday phenomena.

Second, we should recognize that co-existence, even cooperation, between faith and science is possible, though it does require some compromises. People of religious faith should recognize that one cannot challenge scientific facts

with ideas alone and that many more unforeseen natural phenomena revolutionizing previously held worldviews may still be discovered. Scientists, in turn, should recognize that some people—including some scientists—will always need religion for spiritual guidance and comfort and will always have questions concerning the “why of things” to which the scientific method cannot provide answers. Religion should turn away from a literal interpretation of its sacred scriptures by recognizing when they were written, by whom, for whom, and for what purpose. Science should turn away from the easy way out offered by the anthropic principle and recognize that natural points of contact between science and religion do exist. Those points include some questions concerning the values of the universal constants; the actual form of physical laws; and the key fluctuations that gave rise to the Big Bang, the appearance of the first living organisms, and the emergence of self-consciousness.

Third, we should be aware of what some influential personalities have declared about the matter. Pope John Paul II stated, “Science can purify religion from error and superstition, and religion can purify science from idolatry and false absolutes,” and “The Bible itself speaks to us of the origin of the universe and its makeup, not in order to provide us with a scientific treatise but in order to state the correct relationships of man with God and with the universe.”² And Werner Heisenberg wrote,

Science deals with the objective, material world. . . . Religion, on the other hand, deals with the world of values. It considers what ought to be or what we ought to do, not what is. In science we are concerned to discover what is true or false; in religion with what is good or evil, noble or base. Science is the basis of technology, religion the basis of ethics.³

As a physicist, I like to view scientific thought and religious faith as “basis states” of the human brain: They are mutually orthogonal, but at any given time the actual state of the brain can be a superposition of the two without violating the principles of either. Any attempts to force a collapse into one or the other, like the so-called scientific creationists and some agnostics would wish to do, go counter to the very nature of human brain function. In fact, predisposition for religious beliefs and the search for scientific knowledge may even have a

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common evolutionary origin:⁴ the human brain's conception of time, its unique capability of creating images of the future and making long-term predictions, the innate urge to do so, and a feeling of satisfaction when it is done.

References

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As a chemical physicist I have followed both chemistry and physics for more than 40 years. In recent years, I have noticed a gradual change in the language of physics. Physicists now are more willing to accept that our knowledge may be limited and to admit that we will probably never be able to answer the major questions of existence that also fall in the realm of religion. In fact, some modern physics theories are beginning to require a certain belief system of their own and could be criticized as to whether they remain science (Burton Richter discusses this in his Reference Frame in *PHYSICS TODAY*, October 2006, page 8). This change has been noteworthy and has provided for a healthier self-analysis by many physicists. However, I was a little shocked by the Opinion piece by Murray Peshkin, a theoretical physicist. It indicated, unfortunately, that the old arrogance of physics is still very much alive. It appears that a theoretical physicist is needed to present both Darwin's theory of evolution and religion to the general public to help resolve any conflict and emphasize that the theory is supported by extensive experimentation. Peshkin apparently has never read Fred Hoyle's book *Mathematics of Evolution* (Acorn Enterprises, 1999), which severely criticized the theory and outlined its limitations. Many chemists and physicists have great trouble with Darwin's theory, especially if one tries to extrapolate it to higher life forms or modify it from an evolutionary concept to one of creation. If scientists cannot agree no wonder the general public is confused. I am still amused that even NASA justifies

some of its programs in the belief that creation of life forms is some simple mechanism and with luck will be easily found somewhere else.

To extrapolate from nothing to the incredibly complex DNA-replicating molecule takes an even greater leap of faith than any religion. If I give a talk to a general audience, I emphasize the severe limitations of science and our lack of true understanding. We have good models and theories and have made great advances, but we still confuse data and the accumulation of knowledge with true understanding. Moreover, because of our apparently superior knowledge, some people now accept science as their religion.

The older I get, the more I recognize the great commonality between the sciences and the arts. In reality, science is no more than the technical branch of the arts. For example, who was more talented: Albert Einstein, Ludwig van Beethoven, Leonardo da Vinci, or William Shakespeare? Each discipline requires ingenuity, creativity, and insight. One would hope also some wisdom but that is an area that still needs more emphasis and is not taught or easily acquired.

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Being a PhD geneticist and a creationist, I was disappointed that Murray Peshkin did not give references for the statement "Hundreds of Darwin's predicted missing links have been found." I find quite the opposite. The scientific turmoil behind whether birds are descendants of dinosaurs is but one example of how the popular press does not accurately reflect the disagreements in the scientific community. As Storrs Olson, curator of birds for the Smithsonian Institution, stated in a 1999 letter to *National Geographic*,

The idea of feathered dinosaurs and the theropod origin of birds is being actively promulgated by a cadre of zealous scientists acting in concert with certain editors at *Nature* and *National Geographic* who themselves have become outspoken and highly biased proselytizers of the faith. Truth and careful scientific weighing of evidence have been among the first casualties in their program, which is now fast becoming one of the grander scientific hoaxes of our age—the paleontological equivalent of cold fusion.

If Peshkin could provide some solid references, it would add credibility to his opinion.

Also, equating Charles Darwin's and Gregor Mendel's theories does not work for me. Mendel observed inheritance patterns and developed a theory of Mendelian genetics, which is verifiable in simple reproducible experiments. His theory of genetic inheritance provides the mechanism for natural selection, which is observable. Darwin, on the other hand, postulated that natural selection would extend to species changes and therefore provide the mechanism for macroevolution. I have never found that to be observable. As traits are favored through selection, genetic information is reduced, not increased. Man's very behavior exhibited through gene conservation activities is evidence that genetic information is not gained, as required for macroevolution to occur, but is actually lost.

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Peshkin replies: We scientists need to teach the nonscientist public what science is about: what an established theory is and how we know when it's right; how the requirement of falsifiability serves as a fence between science and nonscience, defining the limitations of science and insulating it from attacks based on pseudoscience; and especially why science, correctly understood, does not threaten most people's religious beliefs.

Michael Matthews says that the approach I advocate is condescending to the religious. It has not been so perceived by the several dozen people who have approached me after my public lectures or in response to my writings for the public. A majority of the many who identified themselves as people of religious faith, from high-school students to the former president of a theological seminary, started the conversation by saying that they appreciated my respect for religion. Nevertheless, Matthews's warning should be heeded. People can be hypersensitive to unintended slights about their religion, especially slights from scientists. If you do not have respect for people's religion, you should not be conducting such discussions; if you do have that respect, you should make it obvious from the outset. You don't have to pretend to share your audience's religious beliefs; you only have to respect them. Otherwise, people will tune you out.

Matthews misrepresents the fence I described. It surrounds—and is defined