

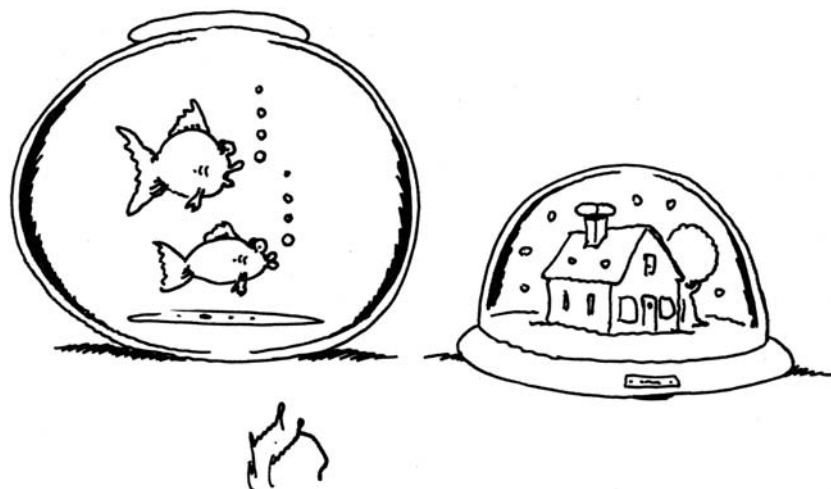
Religious concepts and beliefs are based on the notion of divinity, so one must posit the existence of the supernatural, which transcends nature but may contain all or part of it. The overwhelming majority of Americans subscribe to the existence of such a realm.

A first, reasonable, and useful definition of science is the study of the physical aspect of nature, and its subject matter is data that can be collected, in principle, by purely physical devices. Therefore, the laws of experimental science are generalizations of historical propositions—that is, experimental data. Note that consciousness and rationality are purely nonphysical, since purely physical devices cannot detect them. In addition, life cannot be reduced to the purely physical, so living beings are both physical and nonphysical.

Human rationality develops formal logic and creates mathematics to summarize data into laws of nature that lead to theoretical models covering a wide range of phenomena. However, scientists deal with secondary causes. First causes involve metaphysical (ontological) questions, which regulate science. Without the ontological, neither the generalizations nor the historical propositions of the experimental sciences would be possible.

An extreme form of reductionism supposes that all that exists is purely physical and that the nonphysical aspect of reality follows from the purely physical and the laws governing their interactions. Unfortunately, this is often what is in the mind of the public when discussing evolution. For that reason, one must spell out what prior information is assumed in evolutionary theory; otherwise, people would associate Darwin's evolution with a particular worldview, for instance, atheism. In addition, it ought to be emphasized that advances in medicine and other practical applications of biology are based essentially on the results of laboratory experiments and not the history of the evolution of life on Earth.

The public should be made aware that the laws of experimental science are quite consistent with most theological presuppositions. It is in the study of unique historical events—say, in cosmological or biological evolution—where the conflict between science and religion may arise. For instance, the Christian faith is based solely on the historicity of Jesus of Nazareth, his death, and his resurrection. Absent those historical events, there would be no Christian faith. Experimental science has nothing to say regarding any particular historical event.



"Oh great! Now I'll have to form a whole new cosmology."

Isaac Newton's mechanics and James Clerk Maxwell's electrodynamics are excellent prototypes of scientific theories. No designer or theological considerations are needed in the theories themselves except when considering the nature of the humans who created the mathematical schemes. Therefore, the consideration of humans in any theory must be based on the integration of science with other kinds of knowledge—theology, for example.

The question of origins, especially the origin of man, poses a most difficult problem—in particular, the emergence of life from the purely physical. Surely, the results of experiment are used to analyze all extant data in the historical sciences; nevertheless, the fundamental problem of origins is more a historical rather than a scientific problem.

Finally, Peshkin indicates, "a proposition is not a scientific theory at all unless it's falsifiable in principle." Of course, if one is to apply Karl Popper's principle of falsifiability, a theory must make unambiguous predictions. In weather forecasting, the physics underlying the dynamics is well known, and given the initial conditions, long-range forecasting is very limited indeed. Surely, the evolution of life on Earth is a much more complex system, so the claims made by those advocating evolutionary theory can never really be falsified.

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The issues of scientific validity and science versus pseudoscience were never addressed in any courses I took as

an undergraduate science major, and I observe the same situation in today's university introductory science courses. How are undergraduates—or graduate students, for that matter—supposed to learn these things? Murray Peshkin is correct when he says, "We need to do better."

For about the past five years, I have begun my introductory astronomy courses with a detailed interactive talk on the nature of science and critical thinking. I incorporate a study of logical fallacies, another item missing from most science courses. I use actual letters to the editor of the local newspaper as debunking fodder. This introduction to critical thinking takes about two weeks, but by the end of the semester, my students know how to tell science from pseudoscience and belief, and they know how to gauge the scientific validity of a claim. Instructors who leave this material out of their courses are doing a great injustice to students and to science in general. The presentation I use in my classes is available on my website (<http://www.sticksandshadows.com>) along with a small but growing collection of custom applications of critical thinking to astronomy.

All introductory science courses should be built around critical thinking, with examples from the various scientific disciplines providing applications. If students never understand the nature of science, they will never truly understand how and why we know about exotic entities like black holes.

My experience has been that students welcome discussion on the differences between science and religion, a necessary topic when it comes to criti-

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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