WHAT IS A SCIENTIFIC WORLDVIEW, AND HOW DOES IT BEAR ON THE INTERPLAY OF SCIENCE AND RELIGION?

by Matthew Orr

Abstract. What is a scientific worldview, and why should we care? One worldview can knit together various notions, and therefore understanding a worldview requires analysis of its component parts. Stripped to its minimum, a scientific worldview consists strictly of falsifiable components. Such a worldview, based solely on ideas that can be tested with empirical observation, conforms to the highest levels of objectivity but is severely limited in utility. The limits arise for two reasons: first, many falsifiable ideas cannot be tested adequately until their repercussions already have been felt; second, the reach of science is limited, and ethics, which compose an inevitable part of any useful worldview, are largely unfalsifiable. Thus, a worldview that acts only on scientific components is crippled by a lack of moral relevance. Organized religion traditionally has played a central role in defining moral values, but it lost much of its influence after the discovery that key principles (such as the personal Creator of Genesis) contradict empirical reality. The apparent conundrum is that strictly scientific worldviews are amoral, while many long-held religious worldviews have proven unscientific. The way out of this conundrum is to recognize that *non*scientific ideas, as distinct from *un*scientific ideas, are acceptable components of a scientific worldview, because they do not contradict science. Nonscientific components of a worldview should draw upon scientific findings to explore traditional religious themes, such as faith and taboo. In contrast, unscientific ideas have been falsified and survive only via ignorance, denial, wishful thinking, blind faith, and institutional inertia. A worldview composed of both scientific components and scientifically informed nonscientific components can be both objective and ethically persuasive.

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A century ago, the discoveries of Charles Darwin and Gregor Mendel were new and seemingly at odds with each other. Darwinian evolution was thought to occur gradually, after tiny variations accumulated to produce large changes over long time scales. Darwin noted: "Natural selection is daily and hourly scrutinising, throughout the world, the slightest variations; rejecting those that are bad, preserving and adding up all that are good. . . . We see nothing of these slow changes in progress until the hand of time has marked the lapse of ages" (1859, 66). Although such changes require inheritance, Darwin knew nothing about genetics, a discovery made by his contemporary, Austrian monk Gregor Mendel. Mendel's experiments with garden peas showed that inheritance was coded by genes, with one allele coming from the female and the other from the male.

Mendel's pea experiments at first drew no attention, but their rediscovery in 1900 fostered considerable controversy in the scientific community (Provine 1971). The controversy stemmed from the fact that traits exhibiting Mendelian inheritance—such as yellow versus green flowers, round versus wrinkled peas, or tall versus short plants—differ discontinuously. Further studies revealed that this kind of discontinuous variation had a genetic basis in many organisms, which convinced a group of scientists, now known as the Mendelians, that evolution must occur in jumps. As the Mendelians saw it, evolutionary change occurred when new alleles for a gene entered a population and produced a "hopeful monster" (not their term)—a creature quite different from those that preceded it but hopeful in the sense that the alteration would be adaptive.

In the other camp, the "biometricians," led by Karl Pearson, observed that many important traits, such as beak size or body size, do not occur in discrete units but instead vary gradually. Unlike Mendel's pea plants, which were either tall or short, most animals come in more than just two sizes—so many sizes, in fact, that describing variation in a population required statistical techniques. To the statistically minded biometricians, Mendel's mechanism of inheritance could not account for traits that vary continuously and therefore could not explain Darwinian evolutionary change.

As the controversy built, neither side sought synthesis. William Bateson, one of the leading Mendelians, thought it "impossible to believe" that biometricians had "made an honest attempt to face the facts" and doubted that they were "acting in good faith as genuine seekers of the truth" (Kevles 1980, 442). Bateson's statements could characterize the most polarized elements of either side of the science-religion culture wars. The controversy between the Mendelians and the biometricians is further similar to tensions between science and religion because, in each case, both sides correctly believed that their perspective was true, but both perspectives were incomplete and partially false and required the other to achieve a coherent whole.

The key experiment toward settling the controversy between Mendelians and biometricians was performed by Herman Nilsson-Ehle, who studied kernel color in wheat. Rather than just two colors, like Mendel's peas, wheat-kernel coloration varies across numerous shades from dark red to white in a manner more like the continuous variation studied by the biometricians. Nilsson-Ehle showed, however, that this continuous color variation *was* produced by Mendel's genetic mechanism; the only difference between what he found with wheat and what Mendel found with peas was that multiple genes, not just one, affected wheat-kernel color. With multiple genes affecting one trait, it is possible to produce a range of phenotypic variation.

Thus, the Mendelians were correct to assert that Mendelian mechanisms are the key to inheritance and critical to evolution, and the biometricians were correct to hold that evolution usually occurs gradually, in traits that vary continuously, and not via hopeful monsters.

Both sides in the Mendelian-biometrician debate were right, but by being incomplete both views also were wrong. By bringing the two together, a new and more useful perspective arose that has served as a foundation for modern biology. The reconciliation of Mendelian genetics with Darwinian evolution is known as the Modern Synthesis (Provine 1971).

Unlike evolutionary genetics, religion and science constitute entirely different disciplines with different operating procedures. Faith, for instance, has little place in science, and religion need not be limited to what is empirically observable. But even though they cannot be united as a single discipline, religion and science can be united under a single synthetic worldview. Their synthesis will facilitate progress in guiding the ethical future of humankind.

The American Heritage dictionary defines a worldview as "(1) The overall perspective from which one sees and interprets the world. (2) A collection of beliefs about life and the universe held by an individual or a group" (American Heritage 2000). A worldview that unites science and religion must contain both scientific and religious components while not violating either. How to achieve this is elaborated in the following sections.

Scientific and Nonscientific Components

Stripped to its minimum, a scientific worldview consists strictly of falsifiable components. Such a worldview, based solely on ideas that can be tested with empirical observation, conforms to the highest levels of objectivity but is limited in utility. The limits arise for two reasons: first, many falsifiable ideas cannot be tested adequately until their repercussions already have been felt; second, the reach of science is limited, and ethics, which compose an inevitable part of any useful worldview, are largely unfalsifiable.

As philosopher Mary Midgley put it, "How to live is not a fact, and it could scarcely be any part of a science" (1989, 116).

A scientific worldview may remain so even if nonfactual components are added to it. Nonfactual components can be nonfalsifiable, in which case they are *non*scientific (as distinct from *un*scientific, addressed later). Or, if falsifiable, they cannot be falsified within the time range when relevant ethical choices must be made (Table 1).

I illustrate some of these distinctions using the example of climate change. Climate change is problematic for a variety of reasons. First, individual activities, such as driving a car and heating one's home, which do not conform to long-held and probably innate standards of ethics, are causing the bulk of the problem via carbon emissions (Houghten et al. 2001). Second, climate change is a global problem, requiring a host of nations with sometimes contradictory agendas to behave cooperatively. Third, it is impossible to say with scientific certainty exactly how bad the problem will become (Houghten et al. 2001). Climate scientists cannot conduct repli-

Table 1

Characteristic of component	Component is scientific?	Component disqualifies wider worldview from being scientific?	Examples
Falsifiable			
a. Falsified	No—unscientific	Yes	Literal reading of Genesis
b. Verified	Yes—scientific	No	Evolution Human role in climate change
c. Insufficient evidence	Yes—scientific	No	End point of climate change
d. Unfalsifiable	No—nonscientific	No	Most of ethics

Column 1 shows categories of falsifiability in one component of a worldview; column 2 shows whether the component is scientific; column 3 shows whether the component disqualifies the wider worldview, of which it just one part, from being scientific; column 4 provides examples. Note that a worldview is scientific as long as it contains no falsified components. Ideally, components (c) and (d) should endeavor to draw on scientific knowledge.

cated, controlled studies on our one Earth, and climate models quickly become so complex that it is impossible to predict with precision what will occur under various scenarios of greenhouse-gas emissions. Hence, we are left with a range of future possibilities but without a specific notion of what may lie ahead.

At this point a strictly scientific perspective is held hostage to uncertainty, which leads to a fourth problem with climate change: if we reach the point where the negative effects become insufferable—that is, if the hypothesis of benign levels of climate change becomes falsified—it will be too late to reverse the system. Greenhouse gases have a long residency in the atmosphere, and warming is likely to lead to a self-reinforcing, positive feedback loop of more warming (Philander 1998).

Because of these uncertainties, relevant ethical decisions must be made now, before all of the facts are in. The most sophisticated model run to date puts the upper possible level of future warming at 11 degrees Celsius. A report on the study reads: "Policies aimed at keeping greenhouse-gas levels below a safe threshold may miss the point, says team member Myles Allen, a physicist at the University of Oxford. . . . 'The danger zone is not something in the future,' he says. 'We're in it now'" (Hopkin 2005).

Although humans face critical ethical choices concerning what to do about climate change right now, many scientists still see their duties as discharged once their data fall on the desk of a politician—often a bureaucrat with little scientific expertise and a host of lobbyists breathing down his back. Robert Watson, former chief of the Intergovernmental Panel on Climate Change, has stated, "I believe that national and international [scientific] assessments should not recommend policy action . . . an assessment should be policy relevant and policy neutral" (Sawin 2003, 14). Maybe Watson is right—perhaps it is unwise for practicing scientists to make recommendations to policymakers, since, as Watson notes, individual scientists may not have the expertise needed to evaluate all of the repercussions of their recommendations. But if not scientists, then who? Might knowledge gained through science better translate into the public good if scientists felt encouraged to express nonscientific perspectives?

Scientists may demur from making recommendations that stem from their research by citing a need to preserve their perceived objectivity. But is it "objective" to remain detached from the problems that one's research documents? David Orr writes:

> Mainstream scholars who trouble themselves to think about disappearing species and shattered environments appear to believe that cold rationality, fearless objectivity, and a bit of technology will get the job done. If that were the whole of it, however, the job would have been done decades ago. Except as pejoratives, words such as *emotional bonds, fight,* and *love* are not typical of polite discourse in the sciences or social sciences. To the contrary, excessive emotion about the object of one's study is in some institutions a sufficient reason to banish miscreants to the black hole of committee duty or administration on the grounds that good science

and emotion of any sort are incompatible, a kind of Presbyterian view of science. (Orr 1994, 43)

One reason to wonder, then, about what constitutes a scientific worldview is that it is important to define the range of acceptable behavior for those who think of themselves as holding a scientific worldview. Many who consider themselves scientifically minded constrain themselves (at least in public) to a worldview strictly limited to scientific components. This leads to a limited sort of scientific fundamentalism that, like religious fundamentalism, creates stunted perspectives of limited utility.

There is a wider realm available. Because they do not contradict science, nonscientific components do not disqualify a worldview from being scientific. Moreover, nonscientific components are essential if scientific discoveries are to translate effectively into the kinds of social mores and policies that make a difference. Put differently, nonscientific worldview components are necessary if science is to amount to much more than interesting information or an accurate accounting of the demise of our species and its life-support system.

The Joint Appeal by Religion and Science for the Environment, signed by over one hundred scientists and theologians, states: "What good is all the data in the world without a steadfast moral compass? . . . Insofar as our [environmental] peril arises from a neglect of moral values . . . religion has an essential role to play" (Ackerman et al. 1992). This statement recognizes the need for a more synthetic perspective in addressing environmental problems. But as long as scientists demur from policy recommendations, much less from any tinkering with humankind's moral compass, is such synthesis on the horizon?

Climate change is just one of a growing family of ethical problems created by advanced technology and human population growth. These problems put us in a bind that can be informed by science, but behavioral solutions demand a wider ethical approach. Though informed by research, such problems will also need to draw on such concepts as faith and taboo (elaborated below), which makes them *religious* problems in the most basic sense of the word (Orr 2003).

UNSCIENTIFIC COMPONENTS

The Mendelian-biometrician debate achieved synthesis for three reasons. First, the views of both the Mendelians and the biometricians were based on relatively recent discoveries and thus were free of disruptive historical entrenchments. Second, although each view had different scientific ramifications, they did not carry fundamentally different cosmological consequences, and therefore each view was free of secondary biases. Finally (and most importantly), although their techniques differed (the Mendelians were experimentalists and the Biometricians statisticians), both schools accepted standards of verifiable evidence and repeatable observations for resolving the debate. That is, both sides accepted the scientific method.

In contrast, science-religion debates historically have occurred under very different circumstances. Institutional religion has been around for centuries longer than science, and the scientific discovery most threatening to the cosmology of many institutional religions—evolution by natural selection—is newer still. It is impossible either to shorten the long history of institutional religion and its attendant power structures or to ignore the cosmological consequences of recent scientific discoveries; therefore, these challenges are permanent. However, it is not impossible, at least theoretically, to remove the most important barrier to synthesis: the low priority sometimes given by religion to objective interpretation of empirical evidence.

When the results of empirical inquiry show that something is untrue, that something cannot be part of a scientific worldview. A scientific worldview cannot contain a falsified component. For instance, a literal reading of Genesis is *un*scientific, and therefore it is not a viable component of a scientific worldview (see Table 1).

Fine, some adherents of organized religion might say at this point: you can have your scientific worldview, but I don't want any part of it. Is this response appropriate? Although eliminating falsified notions from religion may seem restrictive, it is no more restrictive than the conditions under which most of today's important organized religions arose. As I have written elsewhere (Orr 2003), few significant religions arose in clear contradiction to the worldviews of their day—however rudimentary, from a scientific perspective, those views were at the time. The Genesis myth, for instance, was such a sensible interpretation of the natural history of its day that key components, such as the rough order of appearance of major taxa on earth, have proven to be correct.

Only after scientific discoveries began to contradict long-held religious notions were people forced to choose between rational thought and traditional religion. Bishop John Shelby Spong writes: "We are not able to endure the mental lobotomy that one suspects is the fate of those who project themselves as the unquestioning religious citizens of our age" (1998, 18). And: "God must be worshiped with the mind as well as the heart . . . any god who is threatened by new truth from any source is clearly dead already" (1998, xix).

There is a second way that eliminating falsified notions from a religious worldview imposes no greater burden on religion than the conditions under which religions often arise. Many religions are founded on a prophetic figure who questioned an existing paradigm to convey a new way of seeing things (Wallace 1956). Arguably, a religious worldview that denies the radical cosmological implications of science violates the seeking mindset that created it in the first place.

The Joint Appeal by Religion and Science for the Environment asks: "What good are the most fervent moral imperatives if we do not understand the dangers and how to avoid them? . . . Insofar as our peril arises from our ignorance of the intricate interconnectedness of nature, science has an essential role to play" (Ackerman et al. 1992). This statement recognizes the importance of knowledge and discovery in modifying moral priorities.

The Appeal avoids asking, however, whether organized religions whose central traditions are rooted in ancient history, and often contradict science, retain much moral authority on contemporary ethical dilemmas posed by science. Can a moral tradition from outside a scientific worldview persuade people to respond to contemporary problems?

What kind of positive movement away from not only our environmental problems but also other problems (inequality, war, oppression) will occur as long as religion is not held to the highest objective standards, and so long as science does not strive to see that the information it produces is put to positive ends? Can either of these things occur in a world where scientific and religious perspectives seldom are synthesized in the same human brain, under a single worldview?

Faith and Taboo

In 1840 James Marsh wrote: "The scheme of Christianity, though not discoverable by reason, is yet in accordance with it—that link follows link by necessary consequence—that religion passes out of the ken of reason only where the eye of reason has reached its own horizon—and that faith is then but its continuation." Marsh's view is consistent with the definition of *faith* as "belief that is not based on proof" (Stein 1982). In contrast, many religions today have turned faith into belief that contradicts proof. Unlike Marsh's view, which is nonscientific, this latter view of faith is unscientific. It leverages "faith" as a rationale for incorporating falsified elements into a worldview. Faith of this sort requires a different name, like "blind faith." As Spong puts it, "Many of us can continue to be believers only if we are able to be honest believers. We want to be people of faith, not people drugged on the narcotic of religion" (1998, 18).

By pointing out the spiritual values of objectivity, knowledge, and reason, and by examining how ethics can be reformulated without a divine parent figure, Spong is working to align Christianity with a scientific worldview. In doing so he converges on ecological and environmental ethics: "I cannot achieve my own destiny except as part of the destiny of my interdependent world. . . . There is an 'objective' wrongness to seeking to cause or to increase the pain of another life. . . . It goes against, if you will, the laws of the universe, which we have called the ultimate laws of God" (1998, 160–61).

From the other end of the spectrum, those with environmental interests are converging on religious principles like taboo and faith. For example, environmentalists wishing to "change the world" have realized that individual behavior means nothing if group behaviors remain static. This leads to a phenomenon that Jane Goodall calls "just me-ism": "My real fear is that we've become apathetic because of what I call 'just me-ism.' I mean, I'm one person, there's millions of people out there. So, what little I can do can't possibly make any difference, it's just me" (Goodall 1997).

Getting past "just me-ism" requires some degree of faith—faith that our actions can make a difference. Like other forms of faith, it is not based on proof, but it does not contradict what is known, either. It is nonscientific, not unscientific. Goodall continues: "But if we turn that around, then as more and more people become environmentally educated, you can have millions, indeed billions, of people all out there saying, 'What I do does matter. I do matter, what I do does matter.' And suddenly you have tremendous environmental change sweeping through our society" (Goodall 1997).

Like faith, taboo has been formalized via religious traditions throughout history. And taboo, like faith, is being renewed as an ethical anchor in light of environmental challenges. Because science often illuminates problems without being able to immediately resolve them, there has grown an increasing appreciation for the nonscientific notion of taboo. In *Living Downstream* (1998), Sandra Steingraber writes:

> Increases in childhood asthma and the clustering of lung cancers around cities with dirty air are telling us something. Suppose we do nothing until the exact mechanisms are elucidated, until exposures are definitely ascertained, until the precise combination of air pollutants and their specific interactions with each other and with the tissues of our respiratory airways are exhaustively understood. Then are we not mimicking those who, at one time, could just as well have claimed that there was not sufficient reason—on the grounds that science had not yet identified any specific biological agent responsible for cholera—to keep human excrement out of drinking water? (p. 188)

In December 2000, officials from 122 nations agreed to a treaty banning a wide range of chemicals, including PCBs and nine pesticides previously banned in at least fifty countries. More important, the treaty required countries to avoid producing *likely* endocrine disrupters and carcinogens. Similarly, in 1997 Australia and New Zealand banned the importation of any plant that may pose a threat as a destructive invader. Plants determined to be risks based on characteristics such as windblown seed dispersal are prevented from entering the country (Kaiser 1999). In such cases, something need not be a proven risk, just a probable one.

These policies are based on the "precautionary principle," which now features prominently in debates over environmental policy. The precautionary principle provides ethical guidelines in the absence of scientific certainty. It shifts the burden of proof from those who are at risk to those who wish to create the risk. In doing so, it draws on rows c and d in Table 1.

Scientific discovery has weakened the ancient cultural formalization of ethics as embodied in traditional religion. Meanwhile, science itself is creating new ethical challenges. Ethics must, therefore, evolve to create standards of behavior that are both compelling and relevant. It is likely that needed ethical changes will evolve very slowly if change is pursued only by religious minds that fail to reject what is unscientific and scientific minds that fail to explore what is nonscientific. It is an important step forward, therefore, to clearly elaborate the boundaries of a scientific worldview and for individual scholars to roam freely across that range once it has been defined.

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