Project 2061: Visions of Science, Visions of Ourselves

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***Origins Research*, Spring/Summer 1991**

Although America has long been a world leader in science and technology, American science education is nothing to brag about. When compared with students from 12 other countries, American 12th graders ranked 9th in physic, 11th in chemistry and 13th (dead last) in biology (International Association for the Evaluation of Educational Achievement, 1988). An international study involving 13-year-olds yielded similarly dismal results. Out of twelve student populations, Americans ranked ninth, only slightly ahead of Ireland, French Ontario, and French New Brunswick (Lapointe, et al., 1989).

National studies are distressing as well. According to the most recent report from the National Assessment of Educational Progress, there have been slight improvements in students' understanding of everyday science facts and rudimentary concepts. But, students' ability to reason scientifically has seen no gains and has possibly even declined (Applebee, et al., 1989). Indeed, only 7% of our high school seniors could "infer relationships and draw conclusions using detailed scientific knowledge" (p.22).

In response to this gloomy situation, science educators have launched several initiatives aimed at reforming science education in America. Perhaps the most widely publicized initiative is Project 2061, a massive reform effort sponsored by the American Association for the Advancement of Science. In 1989, the AAAS completed Phase I of this project, the purpose of which was to "establish a conceptual basis for reform by spelling out the knowledge, skills, and attitudes all students should acquire as a consequence of their total school experience form kindergarten through high school" (AAAS, 1989a, p. 3). Phase II of this project, involves transforming the above into "several alternative curriculum models for the use of school districts and states" (p.3). Finally, in Phase III, the emphasis shifts to carrying forward "a widespread collaborative effort...in which many groups active in educational reform will use the resources of Phase I and Phase II to move the nation toward scientific literacy" (p. 4).

Project 2061 promises to be a highly influential effort. It has already had a profound influence on other reform efforts, including California's Science Framework, the authors of which acknowledged their debt to Project 2061. Consequently, anyone who wishes to understand current trends in science education must become familiar with this particular reform effort.

In this article, we evaluate those aspects of Project 2061 that we think are especially relevant to the creation/evolution debate today. Because the scope of Project 2061 is extremely broad, we will not attempt a comprehensive review. We will limit ourselves, therefore, to three substantive areas: the nature of science, the history of science, and evolution. We will also limit ourselves primarily to two documents.

The first document, *Science for All Americans*, is the overview report drafted by the staff of Project 2061. The largest of all the documents, this report summarizes the purpose of the project and broadly outlines the knowledge, skills, and attitudes that every student should acquire between kindergarten and twelfth grade in the areas of science, math, and technology. The second document, entitled *Biological and Health Sciences*, is one of five reports generated by panels of specialists in certain areas. This particular panel report presents several recommendations about the knowledge and skills that constitute literacy in the biological and health sciences. The other panel reports provide a similar service in the areas of mathematics; the physical and information sciences and engineering; the social and behavioral sciences; and technology. A comprehensive review would consider all of these documents. But for the present, the two documents we have named will provide us with ample material.

The Nature of Science

> *The theorist who maintains that science is the be all and end all—that what is not in science books is not worth knowing—is an ideologist with a peculiar and distorted doctrine of his own. For him, science is no longer a sector of the cognitive enterprise but an all-inclusive world-view. This is the doctrine not of science but of scientism. To take this stance is not to celebrate science but to distort it…*

Nicholas Recher, *The Limits of Science*.

One of the distinguishing characteristics of modern Western culture is its high regard for science. It is difficult to overstate the prestige of science in our culture. This prestige is evident not only in the vast sums of money that governments and corporations pour into scientific research, but is evident on a more mundane level, as well. Consider, for the example, the effect of calling something scientific. In our culture, this is an effective way to win arguments and sell products. Conversely, while it is almost laughable to call a person or idea heretical, the charge of being unscientific (or "pseudoscientific") is frequently enough to consign people and ideas to the lunatic fringe.

Given the important role that science plays in our culture, it is essential that the educated citizen understand what science is really all about. Recognizing this, the project staff of Project 2061 have devoted the first chapter of *Science for All Americans* to discussing the nature of science. In this part of our review, we consider the image of science portrayed in that chapter and evaluate its adequacy as a genuine reflection of this highly regarded enterprise.

The chapter on the nature of science is divided into three sections. In the first section, they discuss what they call "the scientific world view, " i.e. certain basic beliefs and attitudes that scientists share concerning "what they do and how they view their work. These have to do with the nature of the world and what can be learned about it." Conveniently, these beliefs are summarized by the subheadings in this section: the world is understandable, scientific ideas are subject to change, scientific knowledge is durable, and science cannot provide complete answers to all questions.

The second section describes the nature of scientific inquiry and enumerates "certain features of science that give it a distinctive character as a mode of inquiry." Again, these features are summarized under separate subheadings: science demands evidence, science is a blend of logic and imagination, science explains and predicts, scientists try to identify and avoid bias, and science is not authoritarian.

The third and final section describes science as an enterprise that has "individual, social, and institutional dimensions." In this section the authors assert that science is a complex social activity, that it is organized into content disciplines and conducted in various institutions, that there are generally accepted ethical principles in the conduct of science and that scientist participate in public affairs both as specialists and as citizens.

Although the chapter is, in general, a carefully written document, the authors present a seriously distorted picture of the nature of science. To appreciate the nature of this problem it will be helpful to borrow a term from the social sciences: ***ethnocentrism***. Although this term is frequently misused as a general expression of disapprobation—roughly synonymous with close mindedness, intolerance, or bigotry—it also has more legitimate use as a technical term. As used in the social sciences, ethnocentrism refers roughly to the tendency of many social groups to view the world exclusively in terms of their own cultural categories, i.e. to judge everyone by the group's standards. It refers, as well, to the tendency of a social group to assume that their own customs and thought patterns are superior to those of other groups. Ethnocentrism is also frequently marked by a tendency to lump together all outsiders as "foreigners" or "barbarians" or simply as "all those other folks." The result of this lumping together is that those inside the social group understand very little about the outside world—and arguably understand less than they might about their own.

When we look at *Science for All Americans*, we see that the authors' portrayal of science suffers from something closely akin to ethnocentrism—or what some observers might call ***scientism***. First of all, the authors' account is marked by a singular tendency to make science the measure of genuine knowledge:

> There are many matters that cannot usefully be examined in a scientific way. There are, for instance, beliefs that—by their very nature—cannot be proved or disproved (such as the existence of supernatural powers and beings, or the true purposes of life). In other cases, a scientific approach that may be valid is likely to be rejected as irrelevant by people who hold to certain beliefs (such as in miracle fortune-telling, astrology, and superstition). Nor do scientists have the means to settle issues concerning good and evil…) p.26).

The implications here is that if something is not scientific, it is not genuine knowledge. (Note also the apparent implication that science deals with matters that can be ***proven*** or ***disproven***.) This is scientific ethnocentrism—or scientism—pure and simple. As philosopher J. P. Moreland puts it:

> According to this view, science is the very paradigm of truth and rationality. If something does not square with currently well established scientific beliefs, if it is

> not within the domain of entities appropriate for scientific investigation, or if it is not amenable to scientific methodology, then it is not true or rational. Everything outside of science is a matter of mere belief and subjective opinion, of which rational assessment is impossible. Science, exclusively and ideally, is our model of intellectual excellence (1989, p. 104).

To be fair, the authors probably do not mean to imply that all deciplines outside of science are irrational. Indeed, they would probably assert that many academic disciplines do use scientific or quasi-scientific methods, and to that extent can discover reliable knowledge. However, to assert this is still to use "science" (rather than, say "sound reasoning") as the standard of rationality and thereby fall into the grip of scientism once more.

In contrast to this view, in which science is the paradigm of rationality, consider the following statement by philosopher John Ekes:

> A successful argument for science being the paradigm of rationality must be based on the demonstration that the presuppositions of science are preferable to other presuppositions. That demonstration requires showing that science, relying on these presuppositions, is better at solving some problems and achieving some ideals better than its competitors. But showing this cannot be the task of science. It is, in fact, one task of philosophy. Thus the enterprise of justifying the presuppositions of science by showing that with their help science is the best way of solving certain problems and achieving some ideals is a necessary precondition of the justification of science. Hence philosophy, and not science, is a stronger candidate for being the paradigm of rationality (1980).

Consistent with a scientific outlook, the authors tend to over emphasize the durability of scientific knowledge. For example, the authors make the following assertion:

> The modification of ideas, rather than their outright rejection, is the norm in science, as powerful constructs tend to survive and grow more precise and to become widely accepted. For example, in formulating the theory of relativity, Albert Einstein did not discard the Newtonian laws of motion but rather showed them to be only an approximation of limited application within a more general concept .…Moreover, the growing ability of scientists to make accurate predictions about natural phenomena provides convincing evidence that we really are gaining in our understanding of how the world works. Continuity and stability are as characteristic as change is, and confidence is as prevalent as tentativeness (p. 26).

The authors are certainly correct in their assertion about the prevalence of confidence in science. But is it really true that continuity and the modification of ideas—rather than their outright rejection—is the norm? The history of science seems to tell us otherwise. Compare the Copernican model with the Ptolemaic model, nineteenth century creationist biology with evolution, oxygen theory with phlogiston chemistry, place tectonics with contracting world theories. Were these mere refinements?

Even when theories retain many points of commonality with their predecessors, it is not necessarily true that simple refinement has take place. For example, when two theories share the same terminology, it is often the case that the terminology refers to very different things. Were Dalton and Bohr really talking about the same thing when the spoke about the atom? Were Newton and Einstein referring to the same underlying concept when they spoke about mass?

Furthermore, even though a theory is successful at making predictions, this in itself signifies little about its approximate truth. Consider the following list of "successful" theories that were later rejected as false:

> The humoral theory of medicine
> The effluvial theory of static electricity
> The phlogiston theory of chemistry
> The caloric theory of heat
> The vibratory theory of heat
> The vital force theories of physiology
> The theory of circular inertia
> Theories of spontaneous generation
> (from Laudan, 1985,p.121).

Thus, while refinement certainly takes place *within* specific theories, it is misleading to say that modification rather than rejection is norm in science.

Finally, in addition to overemphasizing the durability of science, the authors of *Science for All Americans* also overemphasize its distinctness. As we noted earlier, the distinctive features of science are that it demands evidence, is a blend of logic and imagination, explains and predicts, and is not authoritarian. Moreover, the practitioners of science try to identify and avoid bias.

But is science really distinguished from other disciplines by these characteristics? Consider prediction, for example. Is it true that all scientific explanations involve prediction? No. Many theories, especially in the historical sciences, make no predictions at all, but merely offer explanations after the fact. Conversely, one might also argue that

> Disciplines outside science use prediction as well. Historians predict that future events will obtain given certain circumstance or that new data will continue to verify certain explanations of a historical period after further research, and these predictions often are based on historical generalizations…Theologians can also make predictions. For example, one could predict that if certain spiritual disciplines are practiced, then certain religious experiences or certain patterns in one's family system will follow. Again one could predict that if religious awakening takes place, then certain results based on New Testament teaching should follow (Moreland, 1989, pp. 38-39).

A similar point could be made about the objectivity of scientists—i.e. about their willingness to identify and avoid bias. Science is not unique in the emphasis it places on avoiding bias.

Moreover, in actual practice, dogmatism is a persistent characteristic scientific practice—as Kuhn (1962) and many others have pointed out.

By overemphasizing the distinctiveness of science, the authors reveal not only an idealized image of science but an impoverished understanding of the "outside world" and "all those other disciplines." And once again, we see scientific ethnocentrism raising its head.

On examining the portrayal of science in *Science for All Americans*, it is difficult to escape the conclusion that scientism rather than science is the guiding light of the authors. Given that Project 2061 is intended to guide science education in our country for the next several decades, this is serious indeed. For if science educators succeed in implementing the recommendations of this document, science education will merely perpetuate the biases of our country's educational elite—substituting slogans and platitudes for serious understanding.

The History of Science

Thought and memory each morning fly
Over the vast earth"
Thought, I fear may fail to return,
But I fear more for Memory.

"The Lay of Grimnir," *The Elder Edda*.

History has always been important to human civilizations. By learning about history we seek to understand our identity and perhaps even discover something about our destiny. All too often, however, history shades over into folklore and mythology, becoming an ideological tool rather than a vehicle of understanding. Historian Eugen Rosenstock-Huessy understood this well when he wrote:

> Pragmatic research is easily replaced by mythology; forgeries are welcomed which do away with petty particularities. The eyes of eternity scorn accurate detail and date (Rosenstock-Huessy, 1938 p.124).

Mythology is a potent tool for shaping minds. Masquerading as history, it can forcefully communicate the "truth" of whatever ideas it embodies and make empty platitudes seem like inescapable certainties. This power, long recognized by rules, has been used time and again to consolidate power and legitimize all manners of actions and ideas. It is virtually important, therefore, to pay close attention to the kind of history that is being taught in schools. We must be sure that this history presents a balanced picture of the past, rather than someone's narrow ideology. As Rosenstock-Hussey warned, "History-writing, in any responsible sense, cannot compromise with any group's one-sided myth or tales or holidays" (1938, pp.124-125).

For that reason, it is important to examine what the authors of *Science for All Am*ericans have to say about the history of science and how it should be taught. Indeed, it is doubly important because the history of science has been abused in the past, and the effects of this abuse are with us today.

In particular, John William Draper (1847) and Andrew Dickson White (1896) first made popular the notion that science and religion have long been at war with one another. Although this view has been thoroughly debunked by more recent scholarship (Linberg and Numbers, 1986), the "warfare" myth still holds sway over popular imagination. Worse yet, this myth has been used countless times to ridicule or intimidate those of a religious persuasion—and the view still prevails that religion and obscurantism go hand in hand. We must ensure, therefore, that the history of science is not taught in a way that perpetuates this kind of mythology.

The authors of *Science for All Americans* discuss the history of science in the tenth chapter, entitled "Historical Perspectives." The first section of the chapter (actually the first page) contains some general recommendations on how this topic should be approached. The remainder of the chapter then briefly describes ten selected episodes in the history of science.

The approach advocated in Chapter Ten is best stated in the author's own words:

> There are two principal reasons for including some knowledge of history among the recommendations. One reason is that generalizations about how the scientific enterprise operates would be empty without concrete examples. Consider, for example, the proposition that new ideas are limited by the context in which they are conceived; are often rejected by the scientific establishment; sometimes spring from unexpected finding; and usually grow slowly, through contributions from many different investigators. Without historical examples, these generalizations would be no more than slogans, however well they might be remembered. For this purpose, any number of episodes might have been selected.
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> A second reason is that some episodes in the history of the scientific endeavor are of surpassing significance for our cultural heritage. Such episodes certainly include Galileo's role in changing our perception of our place in the universe; Newton's demonstration that the same laws apply to motion in the heavens and on earth; Darwin's long observations of the variety and relatedness of life forms that led to his postulating a mechanism for how they came about; Lyell's careful documentation of the unbelievable age of the earth; and Pasteur's identification of infectious disease with tiny organisms that could be seen only under a microscope. These stories stand out among the milestones of the development of all thought in Western civilization (p. 111).

On the surface, at least, this is not an unreasonable approach. Nonetheless, there is cause for concern; for the approach advocated here stands very close to the border between history and mythology. As the above excerpts make clear, the emphasis is not on carefully studying the past to discover what it can tell us. Rather, the approach is more akin to storytelling—i.e. using history to illustrate and drive home certain "truths" about the scientific enterprise.

This approach is not necessarily bad in itself. But its inherent selectivity leaves room for serious abuse. When the selection and description of historical events is driven by preestablished ideas, "history" can become little more than an endorsement of these ideas—and is bereft of any power to falsify erroneous notions. It becomes tame history, easily conformed to the demands of ideology and political expedience.

It could be argued, of course, that storytelling is unavoidable at the elementary or secondary school level. After all, the effective presentation of material at these levels necessitates a certain amount of simplification and selectivity. There is a difference, however, between "packing things down" to make them understandable and packing them down to illustrate a theme. Depending upon one's purpose, different criteria will be used to select the facts and ideas that will be presented. The resulting "historical accounts" could thus vary tremendously.

In addition to being particularly vulnerable to abuse, the approach advocated in *Science for All Americans* seem rather shallow when compared to other possible approaches. In many ways, the "2061 approach" comes across like a science history version of *NFL Highlights*. While there's nothing really wrong with this, consider the different approaches that might have been taken. For example, instead of studying a hodgepodge of events, one could wrap a comprehensive history of science course around any number of interesting questions:

1. How did what we call natural science emerge over the course of history? How did it come to be regarded as distinct from natural philosophy?

2. What were the forerunners of natural science?

3. What intellectual factors or ideas influenced its development?

4. How did political, social, and cultural factors influence its development? Why did modern science Develop in Western Europe, rather than other parts of the world?

5. What has been the relationship between religion and science in Western society? How have they affected each other?

Not only would such an approach be more comprehensive and systematic than the 2061 approach, it would probably give students a much better understanding of the historical and sociological context of science as a way of knowing.

As mentioned earlier, the bulk of this chapter is devoted to describing ten episodes in the history of science. These episodes were chosen according to the "dual criteria of exemplifying historical themes and having cultural salience." The overall emphasis is on "significant discoveries and changes that exemplify the evolution and impact of scientific knowledge."

The episodes listed had to do with the following areas of scientific knowledge: the planetary earth, universal gravitation, relativity, geologic time, plate tectonics, the conservation of matter, radioactivity and nuclear fission, the evolution of species, the nature of disease, and the Industrial Revolution.

Although the authors state that these episodes clearly meet their criteria of exemplifying historical themes and having cultural salience, they provide no definitions of these criteria. Thus, while one might agree that the episodes are interesting or important, it is never quire clear what really guided their selection. Given the dangers involved in the selective approach that the authors have chosen a clear statement of the selection criteria seems imperative. Yet, the authors provide no such statement.

In view of the above, it is enlightening to examine some of the particular episodes that the author chose—especially their accounts of the Copernican Revolution and the vindication of plate tectonics. To these we now turn.

The first episode the authors discuss in the Copernican Revolution. The title of this episode is "Displacing the Earth from the Center of the Universe." In their description of this episode, the authors briefly describe the work of Ptolemy, Copernicus, Kepler, and Galileo, tracing the development of the Copernican model up to the time of Galileo's trial. Unfortunately, although the authors' facts seem fairly accurate, the overall picture is distorted by important omissions and by the way in which the facts are presented.

Despite much evidence to the contrary, it is still popular to think of the Copernican Revolution as a classic example of warfare between science and religion. To their credit, the authors of *Science for All Americans* scrupulously avoid making any blatant pronouncements to this effect. They also demonstrate appropriate restraint when discussing the life of Galileo and wisely avoid dwelling upon the ever-popular persecution theme when mentioning his trail.

Nevertheless, there are some serious deficiencies in the overall account. First, there is no real indication of the extent to which the scientific community actively opposed the Copernican model. In *Science for All Americans* we read:

> Most scholars perceived too little advantage in a sun-centered model—and too high a cost in giving up the many other ideas associated with the traditional earth-centered model ([p.112).

Moreover, in discussing Galileo's accomplishments, the only active critics that we hear about are "clergy who still believed in Ptolmey's model." In point of fact, some of Galileo's earliest and most bitter opponents came from the scientific establishment. Most astronomers ridiculed Galileo and even accused him of fraud. Indeed, some academics went to amazing lengths to discredit Galileo. Consider, for example, the behavior of Giovanni Magini, professor of astronomy at Bologna:

> Magini became the first academic to draw clergy into such scientific controversies. He prompted a young religious zealot, Francesco Sizi, to publish an incredible book advancing semireligious arguments that there should only be seven planets, and claiming the supposed moons orbiting Jupiter to be an illusion. Although only a popgun, Sizi's book showed the lengths to which Galileo's opponents would go (Hummel, 1986, p.90).

Magini was not alone in employing such tactics. Following the publication of Galileo's *Starry Messenger*, several professors at Pisa formed an alliance with some courtiers at Florence.

This little resistance movement, known as the *Liga*, was led by Florentine philosopher Ludovico delle Colombe.

From about 1611-1613, the Liga made concerted attempts to refute Galileo in the areas of astronomy and physics. Failing that, they resorted to making Galileo's discoveries a religious issue. Galileo responded to their religious objections in his widely circulated *Letter to Castelli*, but his opponents distorted his theological arguments, and soon drew theologians into the fray:

> As copies of that letter circulated freely, battle lines were drawn, with both theologians and courtiers taking sides. Although Galileo had intended to silence illogical objections to Copernicus, his enemies turned his arguments into an occasion for innuendo, misrepresentation and rumor. Throughout 1614 the scientist was accused of undermining Scripture and meddling in theology (Hummel, 1986, p. 95).

Given this kind of opposition from the scientific establishment, it is remarkable that the account in *Science for All Americans* mentions only the clergy's opposition. A more balanced view of history reveals that Galileo's principle opponent was not the religious establishment, but the academic establishment, which essentially used the power of the Catholic church to accomplish their own authoritarian aims—both in the incidents which lead to the Condemnation of 1616 and those which led to Galileo's trial in 1633. By omitting the scientific community's important role in the Galileo affair, the authors present a seriously distorted account of this historical episode.

The account is also distorted in its treatment of Galileo's accomplishments. The authors rightly point out Galileo's many important contributions: that he built and made several significant observations with the newly invented telescope; that he provided important evidence for the Copernican model; that he rebutted many commonly held arguments against a spinning, orbiting earth; and that he demonstrated inconsistencies in the Aristotelian account of motion.

Unfortunately, the authors neglect some important points. In particular, they neglect to tell us that although Galileo mustered many important arguments for the Copernican model, none of them were entirely conclusive. Conclusive physical evidence was not provided until the mid-nineteenth century with the Foucault pendulum and stellar parallax. And ironically, the argument that Galileo considered to be most compelling turned out later to be wrong.

This is no trivial point. If Galileo had actually made his case, the history of science might have turned out differently. Contrary to popular believe, church officials were hardly inflexible or intolerant in their views of the Copernican model. Writing to a theologian who had authored a scriptural defense of Copernicus's views, Cardinal Robert Bellamine, the foremost Catholic theologian of Galileo's day, remarked.

> If there were a true demonstration that the sun is at the center of the world and the earth in the third sphere, and that the sun does not revolve around the earth but the earth around the sun, then we would have to use great care in explaining those passages of Scripture that seem contrary…But I cannot believe that there is such a demonstration until someone shows it to me (Cited in Shea, 1986, p.121).

Galileo failed to provide such a demonstration. Thus, although most Catholic theologians of the day were deeply committed to a literal view of Scripture, it is not true that they rejected the Copernican model despite overwhelming empirical support. Overwhelming empirical support did not yet exist. And the authors of *Science for All Americans* do a disservice by failing to mention this.

At this point, the reader might object to the criticisms being leveled at the authors. After all, nobody can expect them to cover every aspect of the Copernican Revolution—especially not in a brief synopsis. The issue, however, is not a lack of minor qualifying remarks. The issue is one of emphasis: i.e. how the authors use their limited space to describe an historical episode. As this review shows, the authors have presented a one-sided account that significantly distorts the events of the Copernican Revolution. The result is not history, but myth.

To see this a little more clearly, consider another famous episode in the history of science: the battle over plate tectonics. As with the acceptance of the Copernican model, the vindication of plate tectonics represented a major scientific revolution. Moreover, this revolution in geology had several things in common with the Copernican Revolution. First and most obviously, both episodes involved a battle against deeply entrenched views. Although geological science did not have behind it the long centuries of tradition that astronomy had, the new views still challenged a time-honored view of geology. As one scientist in the late 1920's remarked, "If we are to believe Wegener's hypothesis, we must forget everything which has been learned in the last 70 years and start all over again" (cited in Miller, 1983, p.52).

Both episodes also involved not only skepticism toward the new ideas, but downright hostility. For example, the president of the American Philosophical Society in Philadelphia characterized the theory of continental drift as "utter … rot." A geologist at a meeting of England's Royal Geographical Society in 1923 remarked that the currently accepted view (the contracting-earth theory) was so well established that nobody who "valued his reputation for scientific sanity" would espouse continental drift.

Pursuing the similarities even further, we find that in both the Copernican episode and the plate tectonics episode, hostility was directed not only toward ideas but toward people as well. We have already seen how both the scientific and theological communities greeted Galileo. A similar reception was accorded to Alfred Wegener, an early defender of the continental drift theory. Geologist Phillip Lake, for example, state, "Wegener is not seeking the truth, he is advocating a cause and is blind to every fact and argument that tells against it." Consider also the following account:

> In November of 1928, Wegener was invited to New York to attend an international symposium sponsored by the American Association of Petroleum Geologists. He eagerly accepted the chance to explain his views, only to find that the few voices of support raised at the meeting were quickly drowned out by a chorus of hostile dissenters, who criticized not only his hypothesis but his scientific credentials as well. One after another, delegates to the symposium stood up to express, with crushing sarcasm, grave doubts about the possibility of

> continental drift. Some barely troubled to justify their rejection of the hypothesis; others demonstrated errors of detail and used them to discredit the whole theory; a few seemed unable to restrain their anger that the whole idea was being seriously considered at all (Miller, 1983, p.51).

Wegener, of course, was never threatened with prison (that option wasn't available to his opponents in the early twentieth century). But he did suffer as a result of advocating his theory of continental drift:

> Despite his undisputed talents as a teacher, and the continuing loyalty of his close associates, Wegener remained a mere lecturer and was unable to obtain a professorship in a German university. "One heard time and again," a colleague remembered, "that he had been turned down for a certain chair because he was interested in matters that lay outside its terms of reference" (Miller, 1983, p. 51).

Like Galileo, Wegener was not entirely without supporters. Thus, he eventually took a position at the University of Graz in Austria, where a sympathetic administration had created a position especially for him. Nonetheless, the overall picture is that the scientific community harassed Wegener, just as it did Galileo, with whatever means it could muster.

Turning to the presentation of this episode in *Science for All Americans*, we find only the barest hint of what transpired in the battle over place tectonics. When the authors discuss Wegener's contributions, they barely hint at the level of controversy surrounding his theory—nor is there any clue as to character of this controversy:

> …The idea had little acceptance (and strong opposition) until—with the development of new techniques and instruments—still more evidence accumulated (p.115).

Any parallels between the Copernican Revolution and the battles over plate tectonics are completely ignored. This is even clearer when we look at the final paragraphs of each account. Discussing the final vindication of continental drift, the authors proclaim:

> The theory of plate tectonics was finally accepted because it was supported by the evidence and because it explained so much that had previously seemed obscure or controversial (p.115).

On the other hand, referring to the ultimate triumph of the Copernican model, they assert:

> Criticism from clergy who still believed in Ptolemy's model—and Galileo's subsequent trial by the Inquisition for his allegedly heretical beliefs—only heightened the attention paid to the issues and thereby accelerated the attention paid to the process of changing generally accepted ideas on what constituted common sense. It also revealed some of the inevitable tensions that are bound to occur whenever scientists come up with radically new idea (p. 113).

Note the difference in emphasis. In both cases, the new ideas are ultimately vindicated. But in the case of Galileo, science wins the day over religious bigotry, while in the case of plate tectonics, superior evidence naturally leads to acceptance of the theory. Although the words in both quotations are true enough, they become utterly false when represented as the whole picture—or as an "historical theme."

After examining the accounts of the Copernican Revolution and the controversy over plate tectonics, it is difficult to escape the conclusion that the authors have—regrettably—crossed the line from history to mythology. Only this is not the kind of mythology one might associate with the tales of ancient Greece or Iceland. It is a modern mythology, a mythology that seems more than a little reluctant to acknowledge that sometimes scientists can be their own worst enemies…a mythology in which the most terrifying nightmare is not the twilight of the gods, but their triumph.

Evolution

> *In modern, that is, in evolutionary, thought, Man stands at the top of a stair whose foot is lost in obscurity; in [medieval thought] he stands at the bottom of a stair whose top is invisible with light.*
>
> *C.S. Lewis*, The Discarded Image

One of the thrusts of Project 2061 is to teach science around a group of central themes. Chapter 11 of *Science for All Americans* identifies those themes as 1) systems, 2) models, 3) constancy, 4) patterns of change, 5) scale and 6) evolution. Theses are taught as "ideas that transcend disciplinary boundaries and prove fruitful in explanation, in theory, in observation and in design."

In the most general terms, evolution is simply defined as change. Therefore, in *Science for All Americans,* we find that the concept of evolution applies not only to the physical and biological worlds, but also more loosely to language, literature, music, political parties, nations, and all of science (p.129).

What seems to be lacking is a distinction between "observable evolution" and "theoretical evolution." In other words, what is subtly communicated is the conclusion that since nations change, politics change, music changes, and life itself changes, then life must have changed itself over billions of years from simple organism to the present human form. Much confusion would been avoided if the authors of *Science for All Americans* and those of the accompanying panel report on biological and health sciences would clearly define what kind of evolution they were referring to throughout the project: evolution as a fact (things change over time), evolution as a hypothetical process (organisms are related by descent through common ancestry) or evolution as a hypothetical explanatory mechanism (neo-Darwinism) (Thomson, 1982).

In the biology panel report we find that Project 2061 promotes evolution not only as a central theme, but as the unifying theme without which biology would not exist:

> Central to our understanding of the biological world is Charles Darwin's concept of evolution, which allows us to envision the history of life from its earliest beginnings to the present day. In presenting evolutionary history, it is appropriate to describe what biologists now think happened, giving the major pieces of evidence as well as pointing out the gaps in the story; and it is also appropriate to point out some of our past errors in telling the story. Current evidence that evolution has indeed occurred—and is occurring—is so strong, however, that although many details remain to be explained, evolution cannot be taught as merely one of a number of plausible explanations for how life came into existence (AAAS 1989b, p.3).

Although the panel members rightly advocate "pointing out the gaps in the story," these gaps are nowhere identified and the story of evolution is told with all the dogmatism of unassailable belief. Apparently the gaps are only temporary voids of knowledge that will some day be filled in. To the skeptic, however, the gaps represent critical points at which the theory will either be vindicated or falsified. The following statements about the origin of life reveal that neither the author of *Science for All Americans* nor the panel members leave much room for skepticism.

> The earth's present-day life forms have evolved from common ancestors reaching back to the simplest one-cell organisms about three billion years ago (AAAS, 1989a, p.63).

> Although we do not (and may never) know exactly how life in fact originated, several quite plausible theories have been proposed for the spontaneous formation of complex molecules on primitive earth and for their gradual coalescence into reproducing entities (AAAS, 1989b, p.18).

Anyone who has read some of the more recent works on the topic (Shapiro, 1986 or Thaxton et.al, 1984, Dose, 1988) would want to change "quite plausible theories" to "highly improbable theories."

Another area where there should have been a "healthy spirit of questioning" (AAAS, 1989a, p. 149) is in the area of protein homology. Instead of identifying the many examples of conflicting evidence in protein homology (Ayala, 1978; Ambler & Wynn, 1973; Ambler et. al, 1979; Schwabe, 1986; Schwabe & Warr, 1984; Denton 1986) and the wide state of confusion in the field in general (Scherer, 1989), the authors of *Science for All Americans* simply state:

> The closeness or remoteness of the relationship between organisms can be inferred from the extent to which their DNA sequences are similar. The relatedness of organisms inferred from similarity in their molecular structure closely matches the classification based on anatomical similarities (AAAS, 1989a, p. 60).

Again it is ironic that *Science for All Americans* on one page (150) encourages students to experience science as a way of knowing, not as a body of static unalterable truths, while elsewhere telling them that there is no longer a debate about whether evolution occurred—only on the minor details of *how* it occurred (p. 118). Indeed, the authors go on to imply that educated scientists all accept evolution as fact and that the only people who reject evolution are members of the "general public" with religious convictions.

Much of our criticism on these topics could easily have been avoided if the authors had identified "the evidence for evolution" as simply the best that evolution theory has to offer today, and then devoted ample space to the "gaps in the story" of evolution. After all, science is a process, not unalterable truth.

Even more distressing than the treatment of evolutionary theory as fact is the evolutionary "mental framework" or world-view that Project 201 promotes in the name of science. Throughout *Science for All Americans* and the panel report we find multiple references to the need for "mental visions of reality: or conceptual frameworks on which to hang the facts of biology. Had this framework been some lower-level model for organizing specific concepts, we would have fewer concerns. But instead we find on the third page of the panel report that the goal of the new biology is to give each person "a sense of humankind's evolutionary place in cosmic time." Implied in the text that follows is the conviction that if we have the right "mental vision of reality" we will then know how to properly deal with drugs, AIDs, abortion, and environmental problems. This point is driven home a few pages later:

> Earth abounds in a diversity of living creatures, which all interact to some degree. Each type shares properties common to all life, and yet each is different, as a consequence of millions of years of chance evolutionary events. Identifying the differences and tracing their origins provides the mental framework for comprehending the place we humans have in the biosphere, as well as our present impact on it (AAAS, 1989b, p. 16).

This is not science. This is a world-view—namely, philosophical naturalism—masquerading as science: *We are a consequence of chance evolutionary events that took place over millions of years, and if we grasp this mental vision of reality we will be able to properly interact and react to life around us.*

Organizing concepts are necessary and appropriate in science education. But when they are as broad as the ones in Project 2061, science becomes a tool for promoting philosophical and ideological viewpoints. Although science educators may find these viewpoints attractive, even compelling, they are not thereby warranted in passing off these views as science. Our students—and our society—deserve better than that.

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This article originally appeared in Origins Research*, 14:1 (Spring/Summer, 1991).*